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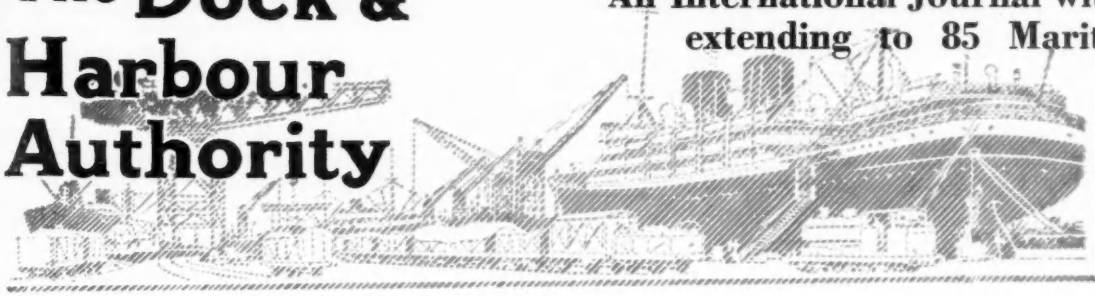


Editorial Notes

Clydeholm Shipyard

It cannot be said of British shipbuilders that they do not seem able to build a wide range of specialised products. But it has been questioned whether they build any ships as efficiently as their principal competitors and whether, in particular, they have kept abreast of all the latest advances in marine propulsion. This broadly, has been the theme of a much-leaked report of the Department of Scientific and Industrial Research which was eventually made public at the end of last year. Any comprehensive survey of an entire industry which contains some of the largest and best equipped shipyards in the world as well as a multiplicity of smaller yards— perhaps too many—may unconsciously convey a public image of an industry (if we may employ the current idiom) as being somewhat old fashioned, through a tendency to compare the average performance at home with the latest and best selected practice elsewhere. Efficiency in this connection is notoriously difficult to evaluate, however. There are many who will argue that the smaller units have no place in the modern working conditions in the industry despite the fact that they are repositories of a long tradition of designing skill and of real craftsmanship, for shipbuilding as distinct from ship repairing is becoming more and more an assembly industry, requiring different skills (though of the same high order) and, above all, space and a vast capital investment in equipment and facilities.

As an example of this and to keep the record straight, we print in this issue a description of the Clydeholm shipyard of Messrs. Barclay, Curle and Company (now an affiliate of the Swan, Hunter Group) who also own a well known repair establishment at Elderslie, likewise on the Clyde. Here indeed is an illustration of what can be accomplished by enterprising shipbuilders working in association with consultants and engineering specialists who give expression to a clearly formulated requirement. Yet it is only one instance of what has been going on throughout the British shipbuilding industry in recent years. It will be observed that the yard is arranged primarily to permit the fabrication and placing of large all-welded sub-assemblies which greatly assist the control and overall speed of construction, although it can be the bugbear of ship repairers faced with the problem of avoiding locked-up stresses when renewing wasted shell plates and bulkheads—a factor which will focus even more attention on the improvements in surface treatments and in cathodic protection which are now being made.

The decline in shipbuilding activity in United Kingdom yards has been more talked about than apparent during the last three or four years but it may now begin to show more clearly. British yards worked steadily through their order books during 1960 and launched nearly 1.3 million tons, about 3½ per cent less than in the previous year but still within 10 per cent of the industry's peak output post-war. The fall in output has been appreciably less than in countries which lately have been doing the work more quickly. If British yards had been able to finish ships as quickly as their rivals they might have gained a bigger share of the surge of orders in the middle '50's but in that case they might conceivably have been worse off now. But speed of completion is of the greatest importance where such great sums of money are involved and now is the time when yards such as Clydeholm will show their paces, and reap the reward of their initiative.

Pipeline Legislation

The Minister of Power has announced in the House of Commons that the development of privately owned pipelines is to be governed in future by new general legislation instead of being sanctioned piecemeal by a succession of private Acts of Parliament. The granting of powers of compulsory purchase to private concerns building pipelines which do not as yet rank as public utilities caused the Select Committee considering the Esso project for a white oil pipeline from Fawley on Southampton Water, to London Airport and thence to Avonmouth, to recommend that no more such private Bills should be approved. In future, under the new proposals it would seem that there will be better facilities for voicing objections and it will then be for the Minister to decide whether to allow a pipeline to be laid. Where powers of compulsory purchase are sought by the promoter it will still be necessary to obtain Parliamentary approval. No doubt this will do much to secure an orderly development of privately owned pipelines in the public interest. So far, however, it would appear that pipelines are being regarded solely as a means of transporting fuel oils, coming under the jurisdiction of the Ministry of Power, and not for what they may well become, namely, an instrument of transport in general. Such a development has found wide acceptance in other countries—notably in the United States where a common-carrier obligation is imposed upon pipeline promoters.

Circumstances in the United Kingdom are nothing like so favourable for common-carrier pipeline projects, whether they are to be privately or publicly owned and, as no place is very far from the coast, most pipelines are likely to be built for the promoter's own use. Nevertheless, consideration ought to be given to the possibilities of pipeline transport either as an integral part of the British Transport Commission's own transport undertaking or under its licence, if only to avoid duplication and uneconomic competition between what may otherwise prove to be rival transport media. Furthermore, the network of railways and canals can provide wayleaves necessary for pipeline construction with the least possible injurious affection of other interests.

It happens that another private Bill is already before Parliament for a public pipeline from a deepwater tanker terminal in

the lower Thames estuary to various parts of west London. Its promoters envisage it as part of a public pipeline system continuing northwards to the Mersey by way of the industrial Midlands, the one route in the country where a common-carrier pipeline might be worthwhile. If this line can be laid it will follow for almost its entire length the British Waterways Canal System. It is designed mainly for the transport of white oils but can be used to carry liquefied petroleum gases and other pumpable substances. On the score of public safety alone the scheme has much to recommend it. The developers say that they intend to charge a standard published rate to all comers.

Presumably this scheme will now be subject to the new legislative procedure later to be introduced, though apparently the Government is not prepared to find Parliamentary time for it during the present Session. It is to be hoped that such a seemingly worthwhile enterprise will not be unduly delayed but its sponsors have already performed a useful service by drawing public attention to a mode of transport which holds great possibilities for the future when brought within the sphere of appropriate public regulation.

Shipping and Port Facilities

The Annual Report of the Chamber of Shipping of the United Kingdom for the period 1960-1961, made public at the end of February, is, as usual, a mine of information on every aspect of international sea transport. It is, of course, impossible within the confines of a short note to do justice to such a variety of subjects as are contained in some 130 pages of text with more than 40 statistical charts and tables and appendices and if we single out one among so many for particular comment, it is because the Chamber so clearly attaches the most importance to it, rightly so in our judgment. Unquestionably it is the notion of flag discrimination and cargo preference and their related devices as practised today which affects more than any other circumstance the future of economic shipping services for carrying the world's trade.

Much has been written in the past about the interdependence of nations and their growing awareness of the benefits of co-operation and the liberalising of trading relations. While this awareness finds increasing practical expression in the sphere of visible trade—the proposed Organisation for Economic Co-operation and Development is the latest example of this—international shipping is faced almost daily with new restrictions and obstacles in the performance of its essential function as the carrier of world trade. With some three-quarters of the goods moving in international commerce carried by sea, the vital importance of efficient and economic sea transport cannot be exaggerated. Nevertheless, the restrictions and obstacles encountered are steadily undermining the conditions of free and fair competition through which international shipping can best provide its necessary services.

Shipowners are faced with a revival of the narrow restrictionism of the past in the form of a doctrine of economic nationalism on the part of an increasing number of nations in respect to their seaborne trade and, at the same time, with increasing interference on the part of governments in their day-to-day commercial operations. On the first count, in recent years some 40 governments have been actively seeking, in one way or another, to divert to ships of their own flag cargoes which in the normal course would find their way into ships of all flags, dependent, it may be, on current market conditions. Of these 40 governments, some 35 have included in bilateral trade treaties provisions aimed at reserving cargoes moving under these treaties to ships of the two countries concerned. Commercial considerations and the vital spur of competition resulting from the merchant's freedom of choice have been ignored and world trade has been burdened with a wholly unnecessary addition to its transport costs. Unless these policies are discarded, or at least much modified, the Chamber avers, the vast and intricate network of competitive international shipping services on which efficient transport hitherto has depended, must inevitably disappear.

The Chamber reiterates that there is little that shipowners or traders can themselves do to stop this trend. Where cargo is directed to ships of a national flag shipowners are denied an opportunity of competing. In other cases of discrimination where, for example, prohibitive import duties are imposed unless the goods are carried in national-flag ships, it is the exporter who has no option if he wishes to retain his interest in the trade.

Between these two extremes there is a wide field in which other compelling pressures are being brought to bear on traders. This is particularly so with those countries where government departments or national corporations have taken over the role of the private trader. In such cases it is quite feasible for those so minded to direct both exports and imports to ships of the national flag by selling c.i.f. and buying f.o.b.

Although it is the shipowner who first feels the effects of flag discrimination, the merchant and world trade in general are the ultimate sufferers. There are at least some signs that the lesson is being learned. Traders are now recognising the economic consequences of flag discrimination and are voicing their protests. Freedom to ship cargoes in vessels of the trader's own choice will almost certainly be determined by strictly commercial considerations. As long as there is no governmental infringement of this freedom there can be no complaint of flag discrimination.

U.K. Ports under Criticism

The Chamber of Shipping Report also contained suggestions concerning the future of the docks and harbours under the control of the British Transport Commission, and their comments on this and on other specifically domestic issues will be found on a following page. Almost simultaneously with the publication of the Report of the Chamber, there has been sparked off a lively correspondence in *The Times* as a result of an article with the ominous heading "Storms are breaking over British ports." The writer's theme was that the recent development of the ports has been a story of constant struggle to match the changing demands of Britain's trade since before the war. And though much has been done by individual ports in the way of repairing war damage and improving berths, sheds and equipment, the collective result is clearly inadequate. Shipowners complain — except when trade is unusually slack — of valuable ships and cargoes having to wait for days for a vacant berth.

He suggests co-ordinated planning of future developments as they affect both the internal transport system of this country and the various cargo streams, from source to destination. This would mean, first and foremost, a thorough expert study of the present pattern of ports and trade and of possible changes in the future. This study should begin not in the ports but in the hinterlands and should aim at finding the most fruitful lines of development of road, rail and ports to provide efficient and economical channels for cargo movement.

The second suggestion may savour too much of regimentation for some people. It is that a centre should be set up for permanent research into cargo movement in all its aspects — the study of ship types, port facilities, cargo-handling equipment and possible forms of unitization. The criticism is likely to come from those who hold that it is impossible to impose any measure of standardisation on Britain's port system—no two ports are alike; that local port customs vary from area to area; in short, that there is as much individualism in the ports as in any section of the shipping industry. But that, surely, is begging the question: for clearly the industry has not as yet evolved a basic philosophy of working.

The Reconstruction of Clydeholm Shipyard, Glasgow

A Modern Lay-out for Welded Sub-Assemblies

ABOUT six years ago work commenced on the modernisation and large scale reconstruction of Clydeholm Shipyard, belonging to Messrs. Barclay Curle and Company Limited and situated on the north bank of the River Clyde, a few miles downstream from the city of Glasgow. The layout was planned to provide completely new building and plant facilities to streamline shipbuilding production using the latest prefabrication and welding techniques. The reconstruction work has now been completed as far as is intended for the present stage, and includes new berths, travelling crane tracks, steel stockyard, platers' production bays, welding bays for prefabricated sections and a gantry for storage of the prefabricated units. In addition, a new joiners' shop and a general purpose building with canteen, blacksmiths' shop, sub-station, etc. have been included in the layout. A feature of the scheme is the comprehensive provision of cranage and transport facilities to lift up to 60-ton loads and transport these from production shops to any point on the shipbuilding berths.

This extensive rebuilding was made possible by the foresight of Messrs. Barclay Curle in adding to their property many years ago the ground lying between Clydeholm Shipyard and the North British Engine Works. This has proved of inestimable value in the development and reconstruction programme which continued without undue interference with the current shipbuilding construction.

The Consulting Civil Engineers collaborated closely with the staff of the shipbuilders to develop buildings, sheds, trackways, berths, etc. which would most economically, and efficiently, incorporate the needs of the shipbuilders.

Steel Production Shops

The basic idea behind the plan was to provide a straight line production system, steel being delivered by railway to the storage area at the western end. There the steel is sorted and passed into the platers' shed. After processing it is transferred to the marshalling area whence it passes to the assembly shed and finally to the unit storage area or directly to the building berths. The space occupied by storage gantries and buildings extends to 276-ft. wide by 1,215-ft. long.

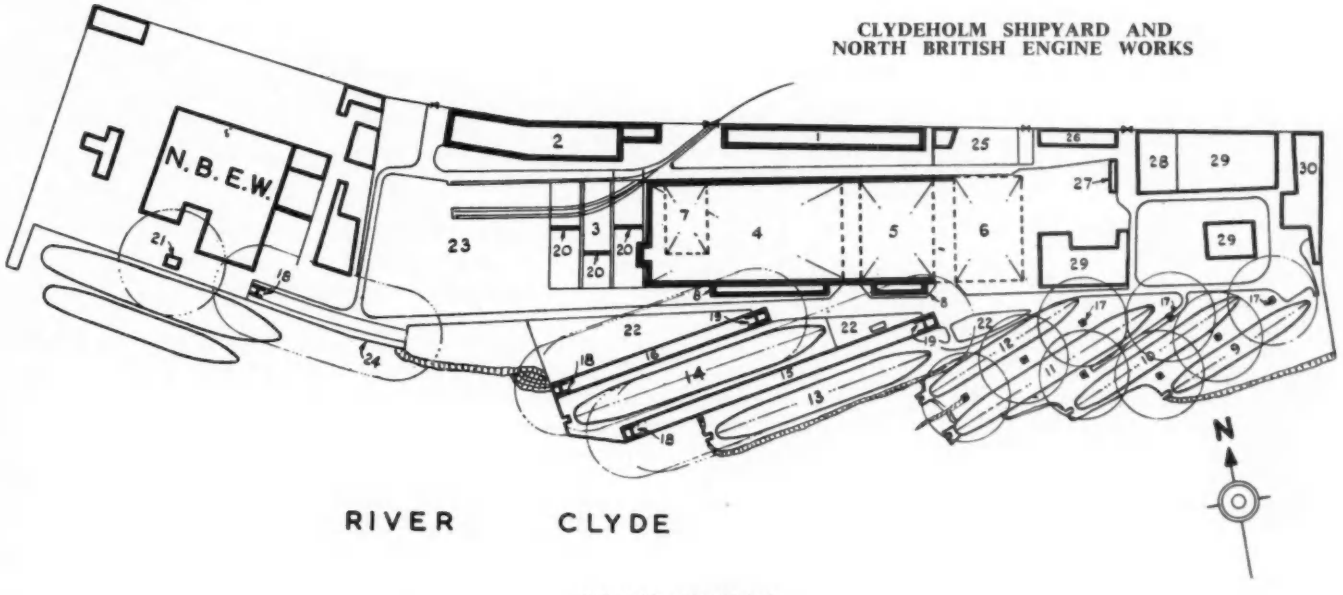
The steel stockyard at the western end occupies a length of 260-ft. and is divided into three bays, one for rolled sections and two for plates. Each bay is served by a 10-ton electric overhead travelling crane of box girder construction. These cranes travel at right angles to the direction of motorised roller conveyors feeding into the platers' shed, and are fitted with vacuum lifting beams for off-loading, sorting and loading plates on to the conveyors.

On entry to the platers' shed the plates pass through an annex building containing hydro-level plate straightening machines to iron the plates to a perfectly flat shape.

From this position adjacent to the storage gantry, the platers' shed extends eastwards for a distance of 500-ft. The overall width is divided into three bays of 90-ft. span; each of these bays is provided with 10-ton overhead travelling cranes on rails 30-ft. above the floor.

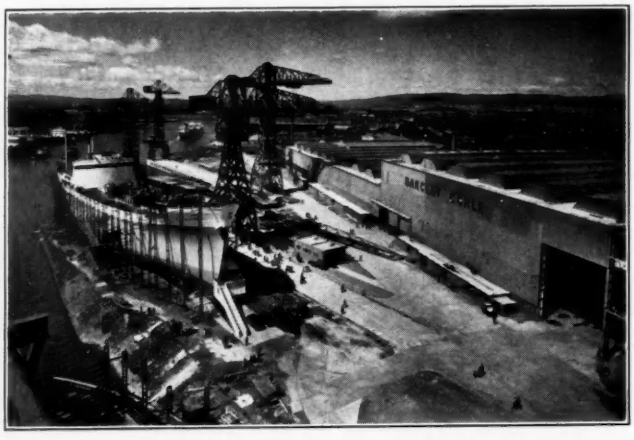
The structural framework of the building is all welded with main frames of I-section columns and beams forming a three-bay portal, the girder sections being built up from flat steel plate. Cranked roof beams span between the main frames forming a

CLYDEHOLM SHIPYARD AND NORTH BRITISH ENGINE WORKS



KEY TO DIAGRAM

1, Workshops, Power House, Canteens, etc.; 2, Joiners' Shop and Boiler House; 3, Steel Stockyard; 4, Platers' Shed; 5, Assembly Shed; 6, Unit Storage Area; 7, Mould Loft over Platers' Shed; 8, Offices and Stores; 9, No. 1 Berth; 10, No. 2 Berth; 11, No. 3 Berth; 12, No. 4 Berth; 13, No. 5 Berth; 14, No. 6 Berth; 15, No. 4 Trackway; 16, No. 5 Trackway; 17, 10-ton Cranes, Berths 1-4; 18, 10-ton Travelling Cranes; 19, 60-ton Travelling Cranes; 20, 10-ton Electric Overhead Cranes; 21, 150-ton Crane; 22, Storage Areas; 23, Area for future development; 24, Extension to Fitting Out Wharf; 25, Car Park; 26, Main Office; 27, Managers' Offices; 28, General Store and Riggers' Loft; 29, Covered Storage; 30 Plumbers' Shop and Paint Shop



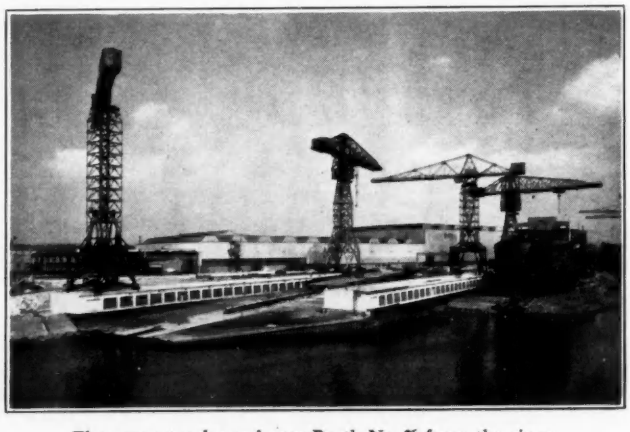
The river frontage of the reconstructed yard with the "City of Sydney" about to be launched from the extended Berth No. 5.

monitor type roof with glazing on the sloping faces of the monitors. A brick dado wall has been built along the perimeter walls to a level of 10-ft. above the ground and above this the sides are clad with corrugated aluminium sheeting. The roof covering is formed with aluminium decking and felt waterproofing.

Over part of the platers' shed there is a mould loft for laying-off and template making. A clear floor area is obtained by the use of 100-ft. span sloped leg portal frames supported by the main building frames and the side walls are continuously glazed.

The middle and south bays of the platers' shed are arranged for speedy and economical handling and processing of plates and in the north bay the sections are worked.

The layout of the plate working area in the platers' shed and the capacity of the various machines and conveyor tables are arranged for the transport and processing of plates having a maximum length of 45-ft. and a maximum width of 12-ft. On entry at the west end of the shed, plates are sorted by a 10-ton Semi-Goliath crane. A plate marking area is located adjacent to the sorting area and after being marked the plates are taken to the various processing machines. In the centre bay there are two Oxyplane flame cutting machines fed by a motorised conveyor 285-ft. long with push button control panels for each machine. From the central control position at each machine the plates are moved along the conveyor from the on-loading position to the flame cutters. Whilst the flame cutting process is in operation, the plate already processed is removed from the off-loading section of the conveyor and another plate is placed on the on-loading section.



The crane tracks and new Berth No. 6 from the river.

Also in the centre bay of the platers' shed is a duplex longitudinal profile cutting machine which flame cuts two plates simultaneously. Two motorised conveyors are provided each 137-ft. long—the handling of the plates on to and off the parallel conveyors being similar to that described for the Oxyplanes. Most of the heavy type plate work such as shell, decks, bulkheads, etc. is processed in the centre bay and the few plates which require to be drilled are transferred to the drilling bed in the south bay by means of a 10-ton power, slewing and hoisting radial jib crane.

The sections can be transported from the steel stockyard to any one of five work stations along the length of the section bay in the platers' shed by a motorised conveyor about 535-ft. long, the movements of this conveyor being automatically controlled by one operator from a cabin located inside the shed high up on the west gable. The appropriate work station to which the section material is to be delivered, e.g., frames to frame work station, is pre-selected on a control panel in the cabin and the conveyor is activated from the same panel. The sections are transferred from the conveyor to off-loading arms which also serve as marking tables. The ships' frames are set by a cold frame bending machine at the west end of this bay. In addition a 70-ft. long oil-fired section heating furnace is provided with furnace blocks and ancillary plant; further east is an area for scrieve boards. A 400-ton hydraulic press is used for joggling the frames and a 2-ton electric overhead travelling crane is used for handling and transporting the sections in the frame working area. East of the frame working area beams, bulkhead stiffeners and similar sectional material are marked, straightened, cambered, joggled or punched as required. After being processed sections are transported to the marshalling zone or to the assembly shed by one of the two 10-ton electric overhead travelling cranes in the north bay. The crane rails for the 10-ton electric overhead travelling crane in this bay have a continuous run from the west gable of the platers' shed to the east end of the unit storage area, a distance of some 950-ft. Between the beam working area and the marshalling zone the lighter class of stiffeners, etc. are worked before being despatched to the marshalling zone or to the assembly shed.

The assembly shed is a continuation of the platers' shed but has a higher roof and additional girders with crane rails to accommodate 30-ton electric overhead travelling cranes 60-ft. above floor level to allow bulkheads, etc. to be turned over. Two 30-ton cranes in the centre and south bays, working in tandem, are used to lift loads of up to 60 tons in both bays. In the north bay, sub-assemblies are prepared and for handling these there are, in addition to two 10-ton overhead cranes, twelve column mounted jib cranes of about 3-ton capacity which help to relieve the 10-ton cranes.

The assembly hall extends for 250-ft. to an open gable end adjoining the unit storage gantry with an additional 50-ft. of canopy roof to improve weather protection at the open gable end. The main building frames of the assembly shed are again of welded portal construction measuring 75-ft. high to the eaves. These main frames carry a monitor type roof similar to the platers' shed with aluminium deck and aluminium side wall cladding.

The floor of the assembly hall is provided with steel angles embedded in the concrete to act as welding skids for the setting out and earthing of ship sections being prefabricated.

Adjoining the assembly shed to the east there is a unit storage gantry for completed fabricated units. This gantry covers the same width as the assembly shed and is 150-ft. in length. The steel frames forming the gantry are identical to those of the assembly shed so as to permit extension of covered assembly space as and when required.

At an early stage in the reconstruction work a comprehensive site investigation was carried out including borings, in-situ and

laboratory soil tests on samples, ground loading tests and pile loading tests. As a result of this, although the buildings are built on a deep layer of loose sand filling overlying silt, piling has only been used for structures close to the river front. All the sheds are founded on reinforced concrete spread foundations using a low bearing value to minimise settlement due to compaction of the sand overlying the soft silt.

On completion, fabricated units can either be delivered directly from the assembly shed to storage areas adjacent to the building berths by means of special heavy duty trailers or, alternatively, units can be carried by the overhead cranes directly into the unit storage gantry where they may lie until required for incorporation in the ship on the berth.

Annexed to the south side dado wall of the sheds, offices and stores for foremen and sub-contractors are provided. These have a reinforced concrete flat slab roof supported on columns with brick panel wall infilling.

Berths and Travelling Crane Tracks

To the south of the new production shop and facing the river, two new crane tracks and a new berth capable of taking oil tankers up to 45,000 d.w.t. carrying capacity have been constructed and in addition an existing berth has been extended. The

The Assembly Shed with Platers' Shed in background 60-ton double bottom units being fabricated in foreground.

crane tracks are 37-ft. between the rails and carry one 10-ton crane and one 60-ton crane on each track. These cranes, which are of the cantilever type, are fitted with automatic proximity warning devices which provide the crane operator with visual indication of the position and distance apart of the two cranes on the same trackway. One of the crane tracks is 609-ft. long and the other 873-ft. long. More than half the length of each track to the river end is on piled foundations, the remainder being on continuous concrete footings. The piles forming the foundations are 14-in. square prestressed concrete up to 96-ft. in length, driven to rock. The piles are very slender and had to be handled carefully but once driven in the ground carry a working load of 70 tons irrespective of length. The piled sections of the crane tracks carry a suspended deck between the crane rails and the space under this deck is utilised for accommodating all the services required on the shipbuilding berths, high tension transformer equipment, welding equipment, water, air and oxy-acetylene services. The crane beams are supported on columns standing on the pile caps and by this arrangement a very flexible distribution of services to the berths becomes possible through the openings provided between the columns. These openings

The extended Fitting Out Wharf.

where not at present used for services, are infilled with brick panel walls and day-lighting panels of transparent fibreglass. This latter material was used to minimise the high risk of fracture at the location adjacent to the shipbuilding berths.

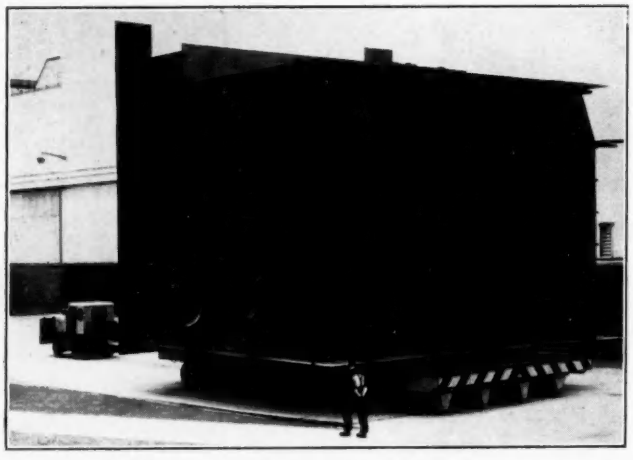
The new building berth is 720-ft. long and 110-ft. wide with a central slab 38-ft. wide. At the upper end of the berth the slab is supported directly on the ground but at the river end for a length of 325-ft. the slab is supported on piles similar to those used on the crane tracks. The launching of a 45,000-ton tanker involves a forepoppet load of about 4,000 tons but due to the short duration of this load on the berth slab the piles under the berth are permitted to carry a higher working load than the crane tracks amounting to about 90 tons on each pile.

Surrounding the berth and crane tracks there are large storage areas which are covered in hardcore and topped with gravel. Also between the production shops and the building berths a broad concrete roadway 50-ft. wide joined to the decks of the crane tracks is provided for convenient transport and distribution of prefabricated units.

Fitting-out Wharf

At the west end of the shipyard where Barclay Curle's North British Engine Works are located the existing mass concrete quay wall has been extended in length by about 150-ft. so that tankers of about 45,000 tons deadweight can be accommodated at the

Vacuum lifting beam in operation in the Steel Stockyard.



60-ton unit being transported to the berth by tractor and trailer.

wharf with their engine room in the vicinity of the 150-ton crane for shipment of main machinery. Although the old wall is constructed as a mass concrete monolith, for economic reasons the extension is formed by a reinforced concrete earth plate slab and walls supported on steel box piles driven to rock with a steel sheet pile retaining wall along the front. The wharf carries a new 10-ton crane track which has been extended along behind the existing monolith wall. A section of this quay crossed the Glasgow Corporation water tunnel passing under the river Clyde and at this location the wharf super-structure spans longitudinally a 50-ft. gap in the pile foundations over the tunnel. The layout of this extension has been planned to allow the quay to be extended further to join up with the end of the west crane track should such an extension be required in the future.

Joiners' Shop and General Purpose Building

To the north-west of the production shops a modern joiners' shop has been built. This building measures 560-ft. by 100-ft. and is located to give ready access to both the building berths and the fitting out quay. The building is in two storeys built in reinforced concrete with a beam and slab intermediate floor and north light barrel vault roof. The top storey includes storage space for ships' furniture and the north light obviates the risk of deterioration due to sunlight. The whole building is out-fitted with modern woodworking machinery, efficient sawdust extraction plant and service ducts. At the east end of this shop there is a boiler house with sufficient capacity to provide for the heating of the shipyard.

The general purpose building measuring 520-ft. long by 66-ft. wide also has two storeys and is framed with steel portals with facing brick walls. It accommodates the workmen's and staff canteens, blacksmiths', shipyard mechanics' and electricians' shops, electricity sub-station and workmen's lavatories.

The photographs show views of the reconstructed shipyard. The Consulting Civil and Structural Engineers were Messrs. Babtie, Shaw and Morton and Messrs. Donald Smith, Seymour and Rooley were consultants for the electrical work.

Transit Shed Loading Platforms

Are They Still Necessary?

By E. S. TOOTH

An important decision to be made when planning dock transit accommodation is whether the shed should have a loading platform at its rear side. Although some authorities hold that such a facility is not required in modern port premises, there are many more who maintain that it is still an important feature. A loading platform has served an excellent purpose in all sorts of premises all over the world for a very long period of time. For manual work, between carrier's vehicle and shed or depot, it has been a tremendous saver of time and energy. It still is. Nevertheless, planning must take care, not of present, but of future needs—known, calculated and even suspected.

The arguments of those who contend that the shed floor should be on the same level as the approach roads are usually based on the belief that, in the reasonably near future, most shore handling of cargo will be done mechanically. This, however, assumes that the revolution which is now taking place in materials handling methods and the improvements which are being made almost daily in ways of packing cargo will continue until, in perhaps 20/30 years' time, most consignments will be tendered to the berth in packages or unit loads suitable and big enough to form satisfactory lifts for mechanical handling appliances. The main argument in favour of dispensing with the loading platform is thus clear; the flush floor allows handling machines to enter and leave the shed without hindrance.

Most port operators would agree that the machine which makes the biggest claim to unrestricted access to the transit shed is the fork lift truck. If this is true, then, unless most consignments transported across the seas will be either packed for fork truck handling or suitable for temporary palletisation in the docks at both ends of their journey, there is no universal answer to our question. Since there is no justification for expecting such a development, our question requires rewording. The problem the port's planning committee has to solve is not **whether** new transit sheds should be constructed with rear loading platforms, but **which** transit sheds should be so designed.

Perhaps the easiest way of tackling this question is to consider its alternative implication. Should the floor of the proposed new shed be flush with its approach roads? If the main reason for constructing a shed in this way is to permit the unrestricted use of mechanical equipment, the further question which arises is: In what circumstances will cargo be handled mechanically?—for, where it will be, there is a strong (although certainly not overwhelming) case for dispensing with the loading platform.

General cargo can be handled mechanically if suitably packed for the purpose or if it lends itself to a dockside mechanical handling system. There is, however, an interesting point to make at this stage. Although imports and exports are the same goods viewed at different times in different ports, they need different handling techniques at each end of their sea voyage. The reason for this is that, as exports they are assembled, whereas at the import berth they must usually be sorted—and sorting has been one of the most difficult obstacles for would-be mechanisers to overcome.

It is because such a small proportion of cargo is tendered for shipment in a form suitable for mechanical handling that special berth-mechanisation schemes have been evolved. In most cases, these have involved the employment of fork lift trucks with dock-owned pallets. The consignments are palletised direct from the tendering vehicle and are handled in load form all the time they are in the custody of the port operating organisation. At manual berths, the individual packages are often handled five times—firstly, from vehicle to hand truck and from truck to shed stow-

age; then, when required by the ship, from shed stowage to truck, from truck to stevedores' slings and from slings to hold stowage. At berths mechanised in the way described, manual handling is only necessary at the time of unloading to vehicle and at the time of stowing in ship's hold—and then not in every case, for the former operation is often performed by a mobile crane or a fork lift truck. In the main, British exports, which include a big proportion of cased, crated and cartoned manufactured goods, lend themselves to this kind of mechanical handling. Thus, where circumstances are suitable, since mechanisation is attended

Photo P.L.A.

Fig. 1. A 20-ft. wide loading platform at rear of a shed newly constructed by the Port of London Authority at Millwall Dock. The shed has no columns but a span of 150-ft.: doorways are 20-ft. high and 20-ft. wide.

by real benefits, machines will be employed. Paradoxically, however, there are instances where the work is done mechanically at a shed with a loading platform—but there is usually a special reason for this and it is doubtful whether in a new construction to serve the same traffic, a loading platform would be provided. If it were, however, it would probably be a very wide one (Fig. 1). This is also the point at which to mention two reasons not directly connected with mechanisation, why a flush floor may be preferred. One is that at some ports it is the practice for lorries bringing or collecting cargo to enter the transit sheds; the other, that at ports catering for the export of motor cars and other vehicles on wheels (Fig. 2) it is always good to have means of access from the vehicle standing ground through the shed to the quay. Pushing or towing export cars round the ends of a transit shed is a slow and costly operation, which also often makes for congestion. Only cargo of suitable construction can be towed without risk of damage and even then special towing equipment has to be used.

Nevertheless, the case for the flush floor does mainly depend on the need or desire to use mechanical equipment and, since this is so, the benefits of mechanisation should be stated clearly. They include speedier ship and vehicle turnround, much greater use of the cubic capacity of the shed, reduced damage and pilferage risks and, of course, less arduous manual labour.

To sum up the export position, it is true to say that only in very rare circumstances will a shipload of cargo be tendered to a berth already packed so that it can be handled mechanically. Nevertheless, at many berths in various countries, general cargo will include a small but important proportion of consignments packed in this way. At a substantial proportion of such berths it will be possible to mechanise the handling of the balance of the cargo, particularly if dock tool pallets are employed. In short, mechanisation is possible at many export berths throughout the world—but there are genuine reasons why even at such berths it will not always be introduced. It may be too expensive; the berth may be used only intermittently for exports; at a common-user berth only certain traffics may lend themselves to mechanical handling; labour may be cheap and plentiful; or there may be no demand for quicker ship turnround.

The import position has already been touched upon. In the deep-sea trades, although there have been many experiments with palletised and specially-packed consignments, there is still little regular traffic suitable for handling by machines. In the short-sea trades, however, there has been more progress. On some routes, cargo is regularly shipped on either merchants' or stevedores' pallets, making mechanical handling possible at the port of discharge. Another method is to leave the sets of exports in the rope slings in which they are lifted aboard so that to the discharging agents the cargo is "pre-slung" and thus more suitable for mechanical handling ashore. A further method, of course, which is still growing in popularity, is shipping in containers. Even this, however, does not produce a standard means of handling in the quay shed. At some berths, the containers are emptied into the shed, the individual consignments being delivered package by package, whilst at others, the containers are delivered from the berth full of cargo. Generally speaking, the former method involves manual handling over a rear loading platform and the latter, mechanisation on a flush floor. Ships built specially to transport cargo in containers are increasing in number. The containers in some of the U.S. coastal traffic measure 17-ft. x 8-ft. x 8-ft. and weigh, loaded, up to 12/15 tons. Mechanical handling of the containers, full or empty, is therefore obligatory.

As already mentioned, the attempt to discharge from ship into shed "loose" import cargo on dock tool pallets is nearly always thwarted by the need to sort to bill of lading marks. In those instances where consignments of suitable cargo are stowed separately in the ship, however, the goods can be loaded on to dock tool pallets in the hold and kept on those pallets until they are tendered to receivers' transport. In each of the operations involved—landing, shedding and subsequently delivering (preferably not across a loading platform—there is a big potential saving

Fig. 2. Motor cars for shipment parked on open ground behind the transit shed. In due course they will all have to be pushed or towed to the quay, either through the shed or round its ends.

in time and labour. Unfortunately, however, since only a comparatively small proportion of general cargo can be handled in this way, full manual gangs are usually required on the quay and if mechanical equipment were provided, it would be used so intermittently as to be uneconomic.

Despite all these difficulties, mechanisation is sometimes found just where one would least expect it. An example of this can be taken from the Port of London, where a partial mechanisation scheme introduced by the Port Authority has produced very

important benefits, particularly to the shipping company. Unexpectedly, it is concerned with the handling of a commodity —cases of citrus fruit—where sorting at landing is a major operation.

At manual berths in London, oranges are landed on to the quay on boards, from which they are hand-trucked to their respective piles. In a vessel bringing, say 30/40,000 cases of Spanish oranges, there may be upwards of 300 different marks. These are always mixed in the ship and the same mark may rise in all holds. Since each mark must be stowed separately in the shed, there must be a large number of truck-men and pilers in each gang. At manually-operated berths in London, the operation of receiving from ship, sorting to separate ownership and piling in shed is done at a speed of 700/750 packages per gang per hour.

It would not be possible to sort such a cargo on to dock tool pallets, which would be the ideal arrangement to ensure speedy mechanical delivery to road and rail vehicle. The array of partly filled pallets littering the shed floor would quickly bring the job to a standstill. Thus, the first step the Port Authority tried was to move the point of unloading the boards from the quay outside the shed door to the middle of the shed itself. This was done simply by substituting dock-tool pallets for the landing boards, so that, when the loads of oranges were placed on the quay by the crane, they could be picked up and conveyed into the shed by fork trucks. The immediate result of this change was to increase the speed of discharge by some 100 packages (2½ pallet-loads) per gang per hour. Since, however, there was now only a short distance between the sorting pitch and the piles, the men soon dispensed with their hand-trucks and carried the goods to their stowages. This released the pilers who then became carriers, so that the bottleneck of the job, instead of being the sorting, became the crane serving the ship. Steps were therefore taken to reduce the amount of slewing and luffing it was necessary for the crane to do. It was positioned carefully in relation to the hold and made to deposit its load on the quay close to the ship's side instead of swinging it round and luffing it across the 50-ft. quay. With these last refinements, the average speed of discharge increased to about 1,000 boxes per hour and in some instances reached 1,250. Although, therefore, this work could only be partly mechanised, the scheme which was introduced resulted in an increase of between 30% and 40% in the speed of landing, which does, of course, mean a real saving in ship turn-round time.

Since, as explained, these cases, although homogeneous, cannot be palletised at the time of sorting, they are usually delivered package by package by manual gangs and the loading platforms with which the sheds in question are equipped, make for greater speed and economy. Even where fork lift trucks and pallets are used, therefore, there is not always a case for a flush floor.

In this section on imports, emphasis has again been put on mechanisation, because it is the most important factor affecting delivery methods. Even if, in due course, a bigger proportion of goods will be palletised or otherwise packed for mechanical handling, there is so far no evidence that the sorting of the remainder ex ship will become so simplified that it will be possible to land **and also tender them to the delivery vehicle** on dock-tool pallets. Thus it seems fair to deduce that a big percentage of cargo—the "loose" goods—will have to be delivered from the shed manually; but even prepalletised consignments, if to be delivered to railway wagon, are often more easily handled by pallet truck across a loading platform. Altogether, it is obvious that the loading platform is likely to serve a useful purpose at most import berths for some time to come.

Enough has now been said for it to be clear that the planning committee must make a separate decision for each shed, taking note of at least the following factors: the purpose for which the berth will be used—imports or exports, the suitability of the traffic for handling by machine, the economic benefits of mechanising the work and the relative costs of the flush floor and the loading platform. If manual handling is to be continued, whether to and from road vehicle or railway wagon, then most likely a loading platform will be preferred; if, however, the new shed is to be worked mechanically, the decision upon dispensing with a loading platform is still by no means an automatic one, but will depend, in the main, upon the kind of handling system it is proposed to introduce. What is absolutely certain, however, is that, so notoriously diverse and changeable is the pattern of port work that both the deliberately provided loading platform and the carefully planned flush floor will sometimes be wrong construction for the particular work in hand . . . . and if, when this is so, the planning committee is not subject to adverse criticism from one source or another, times will certainly have changed!

Book Reviews

"Coast Erosion and Defence"—Hydraulics Research Paper No. 3. Published for the Department of Scientific and Industrial Research by Her Majesty's Stationery Office. Price 1s. 3d.

The answers to some frequently asked questions on coastal protection are provided by the Hydraulics Research Station at Wallingford in a booklet published for the guidance of engineers and coastal authorities. Originally submitted by the Advisory Committee on Sea Defence Research, the nine questions were framed after consultations with a number of engineers responsible for coastal works and they cover the points most often raised.

The aim of the booklet is to set out the most up-to-date information on coast protection, based on both the findings of research and experience in the field. It stresses the complexity of the problems in coastal engineering, resulting as they do from the combined effects of winds, waves, tides and tidal currents, and shows that they cannot be solved by calculations alone.

The nine questions are all strictly practical, and the answers are given in bold English without over use of technical idiom. In particular, the first one contains an admirably clear and concise explanation of the behaviour of gravitational waves in shoaling water—always a source of difficulty when treated in mathematical terms; this paves the way for a thorough understanding of that which follows. Altogether, this is a most valuable and practical contribution to a very complex subject.

Liquid History

To commemorate fifty years of the Port of London Authority, from 1909 to 1959, Sir Arthur Bryant was commissioned to write in brief outline the story of the Authority during that period, and this has now been privately printed.

Although the main purpose of this study is to summarise the achievement of the Authority in its administration and development of the Port and to trace the Port's growth in modern times, the author points out that that very growth is the outcome of 2.000 years of history, and therefore commences the story with the first trading settlement to be established on the Thames. He then outlines the growth of the Port up to 1909 when the entire ownership and control of the 2,700-acre estate containing the docks and 69 miles of tidal river was taken over by the present Port Authority.

During the last half century, the Port has witnessed two world wars—in the second of which the docks system was the most consistently and heavily bombed target in the British Isles—and a most far-reaching social and industrial revolution. Today it operates the largest single dock area in the world.

Some Rehabilitation Works of the Thames Conservancy

Description of Their Design and Construction

By H. C. BOWEN, O.B.E., M.A., M.I.C.E. and W. E. FOSTER, A.M.I.C.E.

(Continued from page 326)

Chertsey Weir

Chertsey Weir, built about 1812, was a shallow-sill weir nearly 500-ft. in length, of an unusual type for the Thames. From its location (shown in Fig. 12) it will be seen that it was a side-spill weir, as contrasted with the more usual deep-sill weirs set at right-angles to the general direction of the stream. Despite its uncommon type, its great length afforded an adequate discharge capacity in flood time. To re-locate it on a new alignment would have been extremely difficult, since a substantial tributary enters the river a short distance downstream of it.

The whole weir consists of three sections. The upstream section, 134-ft. long, was a shallow rymer weir 1-ft. 4½-in. deep. The central section, 153-ft. long was a single tier rymer weir 3-ft. 1½-in. deep. The downstream section, 204-ft. long was a plain concrete overfall without any movable tackle. Originally there was no gangway, and the movable tackle had to be handled by men working in boats, which required skilled watermanship. To obviate this, a gangway was completed in 1951. This was an interim measure, because it was intended in due course to carry out a general reconstruction.

(i) Design

It was decided to retain the plain overfall of 204-ft. length, and to protect it with lines of head and tail sheet-piling. The shallow rymer weirs farther upstream were to be replaced by thirty-seven radial gates aproximately 7-ft. wide and 2-ft. 10-in. deep, set to a common sill level of 36.04 O.D. throughout. The exact widths of the gates varied slightly, to suit the spacing of the existing gangway stanchions, which were to be left undisturbed. Details of these gates are shown in Fig. 13; they are of all-welded construction and are counterbalanced so that they can be lifted by a simple hand chain. This section of the weir was also to be protected with lines of steel sheet-piling driven along the head and tail sides, with the top of every eighth pile anchored by a 1-in. dia. mild-steel tie rod bedded in the concrete apron. As originally planned, the Larssen No. 2 piles on the head side ranged in length from 12-ft. to 20-ft., though in the event a number of much longer piles were used. On the tail side, lengths of 15-ft. to 21-ft. 6-in. were to be used. The old aprons were to be cut out and replaced by new ones, of mass concrete generally 1-ft. 6-in. thick and of nominal 1:2:4 mix, finished to the new sill level.

(ii) Construction

The steel piling to the plain concrete overfall was carried out in the latter part of 1954. This left the part that was to incorporate the new radial gates to be carried out in the following summer, and a start was made in March 1955. The work was to be done one half at a time, leaving the remaining half plus the overfall to take the flow of the river. By the middle of May the lines of steel piles for the first half had been driven, the piles being left high enough to exclude the water so that the apron between them could be cut out and replaced in the dry. The piling had been done with the use of a floating derrick, downstream of the weir, and, as events turned out, it proved extremely fortunate that this was so.

On May 21 the upper and hitherto untouched portion of the weir, which was then taking the flow of the river, suddenly subsided over a considerable length. This caused a drop of about 3-ft. in the level of the reach above the weir; worse still, the whole flow of the river was concentrated through the gap and it was clear that erosion was taking place which would make the gap both wider and deeper. By the time conditions had settled a little, the gap in the weir was about 120-ft. wide and 8-ft. deep, and in it was a jumbled mass of broken concrete and gangway.

It was, of course, obvious that this gap must be closed as soon as possible. There seemed to be a good prospect of doing this by a line of steel sheet-piling, extending from the cofferdam already driven, across the headwater side of the gap to the far abutment of the weir; moreover, the piles could be pitched and driven by the derrick, and held by false walings of timber cantilevered off the piles of the cofferdam. (Fig. 14 is a plan showing what was intended.) But it was also obvious that this process would become increasingly difficult as the gap was narrowed by the advancing line of steel sheet-piling, and as the rush of water through the gap was increased thereby. If this were to be avoided, some alternative route would have to be found for the flow of the river.

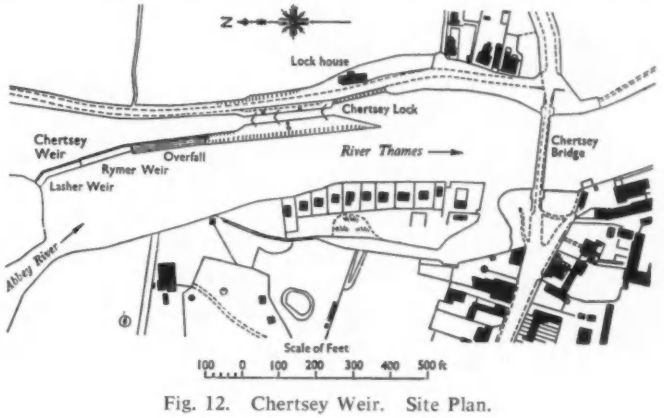


Fig. 12. Chertsey Weir. Site Plan.

To provide this, two out of every three piles in the adjoining cofferdam were driven down level with the existing sill within the cofferdam; this provided some additional discharge capacity at short notice, although not so much, nor at as low a level, as would have been liked. However, provided that the last batch of piles for closing the gap could be pitched rapidly, and provided the flow of the river kept down to the normal for the time of the year, there was every prospect of success. The method was put in hand and all went well for the first few days.

Unfortunately, heavy rainstorms on May 26 caused the river

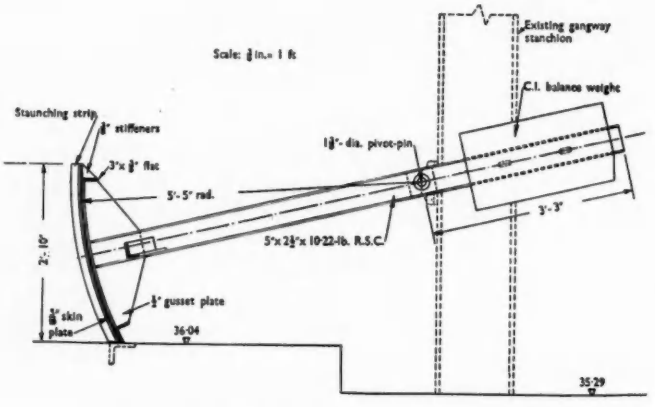


Fig. 13. Chertsey Weir. Detail of Radial Gate.

to rise sharply. Work had to be suspended and the floating derrick had to be withdrawn to safety the next day, and it was not possible to get near the gap for 4 days. On May 31 the flow had dropped sufficiently to make a fresh examination, and it was then found that the depth in the gap had increased to 20-ft. Clearly much longer piles would be required to close the gap, and by good fortune Messrs. W. C. French and Co. of Buckhurst Hill had the necessary piles in stock and were kind enough to provide them at very short notice. Equally clearly further alternative routes for the river flow had to be found. It was accordingly decided to force open the gates of Chertsey Lock and to divert the flow of the river through the lock itself. (It will be appreciated that, because of the breach in the weir, the head on the lock gates was much less than normal.) This was successfully carried out on June 1, using Trewhella hand winches to apply the pull to the gates. This afforded a relief channel 21-ft. wide by about 6-ft. deep. It immediately relieved the rush of water through the gap in the weir to such an extent that pile driving across the gap was completed 4 days later on June 4.

Events proved that the gap was closed just in time, for further heavy rainstorms set in during the night of June 3 and the river rose even more sharply than before. There was no hope of reclosing the lock gates until the spate had run off and it was not until June 16 that this could be done. During this time the dam across the gap in the weir was shored up as well as conditions would allow, and it stood up very satisfactorily without giving undue cause for alarm.

As a result of these events it was decided to rebuild the collapsed portion of the weir first, leaving the adjoining part which was already enclosed within its cofferdam piles till later. By June 25 the tangle of broken concrete and gangway had been removed, and a line of steel sheet-piling along the tail side had been driven. Filling of the scour hole inside the cofferdam was carried out using ballast-pit rejects containing a mixture of flints and chalk. At the same time, the scour hole outside the head dam was filled with similar material. When something near formation level was reached the cofferdam was pumped out and the filling material was found to have consolidated very well. The final layer of filling to formation level was placed and consolidated in the dry and placing of the mass concrete aprons 2-ft. thick followed. No further difficulties occurred during construction.

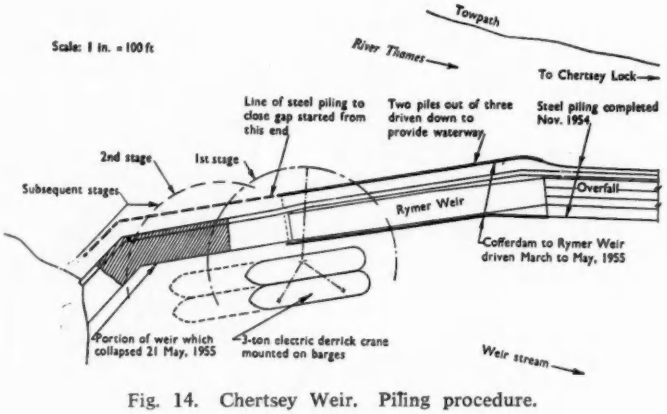

Scale: 1 in. = 100 ft
Towpath
River Thames
To Chertsey Lock
Line of steel piling to close gap started from this end
Two piles out of three driven down to provide waterway
Steel piling completed Nov. 1954
2nd stage
1st stage
Subsequent stages
Overfall
Rymer Weir
Cofferdam to Rymer Weir driven March to May, 1955
Portion of weir which collapsed 21 May, 1955
3-ton electric derrick crane mounted on barges
Weir stream

Fig. 14. Chertsey Weir. Piling procedure.

The collapse of half of this weir while the other half was under reconstruction raises an interesting problem for the engineer concerned in such works. To reconstruct one half at a time is common practice. It has been done on innumerable occasions on the Thames and this is the only occasion on which it has led to trouble; moreover, the trouble came about very rapidly and without any previous indication. On reflection after the event the authors think that the particular weakness of the old weir at Chertsey lay in the absence of any form of sheet-piling cut-off which would prevent percolation under the weir, and more important perhaps, would prevent any such percolation developing rapidly into a large gap. Were such a state of affairs to be encountered on some future occasion, the authors would provide sheet-piling protection to the whole weir before starting the reconstruction of any part of it.

Old Windsor Lock

The first pound lock and the lock cut at Old Windsor were reconstructed in 1838. In 1889 a new lock was built with sides of timber piling and sheeting below water level, surmounted by mass concrete walls faced with blue brickwork. Alternate main piles projected above coping level to terminate in cast-iron pile caps from which tie rods were connected to concrete anchor blocks bedded in the ground. Dimensions of the lock were 134-ft. 8-in. long by 17-ft. 8-in. wide with a depth of 6-ft. 2-in. on the tail sill at normal water level. The invert was of mass concrete with timber sills.

The condition of the underwater timber piling had for some time given cause for serious concern as to the stability of the walls, and as early as 1946 preliminary drawings and estimates were put in hand, for execution when circumstances would allow. Since this would be the first lock to be reconstructed for about 20 years, comparative estimates were prepared for a number of different types of construction, e.g. mass concrete walls and inverts (the time-honoured method); precast inverted portal frames for the side walls and inverts; reinforced concrete cantilever walls; and steel or concrete sheet-piled walls with a mass concrete invert. It was soon apparent that mass concrete walls could be ruled out on the score of cost, and that precast concrete portal frames would be difficult to handle in comparatively restricted sites. There did not appear to be much difference in cost between the use of reinforced concrete compared with steel piling or reinforced concrete piling. However, the use of sheet-piling, whether of steel or concrete, appeared likely to lead to a more rapid construction. It was necessary to complete the work in 6 months, in order not to interrupt summer traffic, and this led to a decision to use steel sheet-piling.

The pressure of work elsewhere caused the reconstruction of Old Windsor Lock to be deferred till the winter of 1953-54. In 1952, when the final designs were put in hand, the supply position for steel sheet-piling was very difficult, and it seemed unlikely that it could be obtained in time. It was therefore decided to use precast concrete sheet-piling instead.

(i) **Design**

The dimensions of the old lock were too small, and the opportunity was therefore taken to increase the size to 179-ft. long by 25-ft. wide by 8-ft. 3-in. deep on both upper and lower sills (Fig. 15). Information about the nature of the substrata was available from a bore hole sunk near the head of the lock in March 1946 and this was supplemented by data from a second bore hole sunk near the tail end of the lock in December 1952. The second bore hole confirmed the results from the first and showed that about 11-ft. of mixed filling material covered 1-ft. 6-in. of peat and river deposit overlying a 12-ft. seam of gravel under which was blue clay. The clay level ranged from 35.00 to 37.75, coinciding closely with the required formation level for the new invert.

The lock sides were designed as anchored sheet-pile walls to take the maximum loads arising during construction or whenever the lock is pumped dry for maintenance.

The sheet-piles (Fig. 16) are 24-in. by 12-in. section having a semi-circular groove down each edge, thus forming a 3-in. dia. grout hole when driven side by side; in all, 304 piles were used. The piles are reinforced with 2 mm. dia. high-tensile steel wire stressed to 90 tons/sq. in., the strongest piles having 392 wires giving a resistance moment of 606,000 in./lb. Concrete stresses are 2,200 lb./sq. in. on the compression side and zero on the tension side. The initial prestressing force was of the order of 168 tons allowing 16% for losses due to creep, etc. $\frac{1}{4}$-in. dia. mild-steel spiral stirruping is provided throughout the length of each pile and two $\frac{1}{2}$-in. dia. mild-steel hoops are cast in the head for bonding with the reinforced concrete capping beam.

A number of 14-in. by 14-in. section piles were used to provide the correct set-back at the gate recesses. Special section piles 14-in. deep by 14-in. wide on the front face and $8\frac{1}{2}$-in. wide at the rear were used to obtain a rounded line of piling in forming the bell-mouth entrances at the head and tail of the lock. A number of the sheet-piles had five Rawlplug cement-in sockets, for $\frac{3}{4}$-in. dia. bolts cast in the front face to provide a fixing for the timber rubbing strips. A reinforced concrete capping beam bonds in the heads of the sheet piles, and mild-steel rods $2\frac{1}{4}$-in. dia., at 10-ft. centres, tie the capping beam back to anchorage of steel sheet-piles.

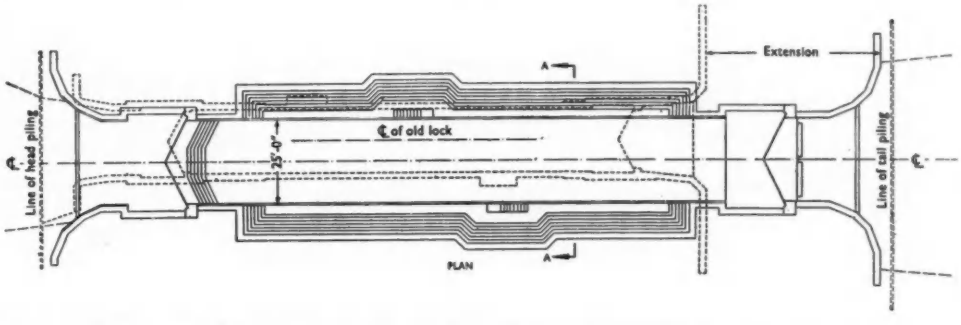


Fig. 15 (left). New lock at Old Windsor.

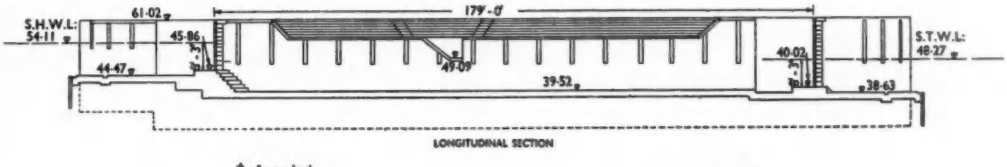


Fig. 16 (bottom left). Prestressed concrete piles.

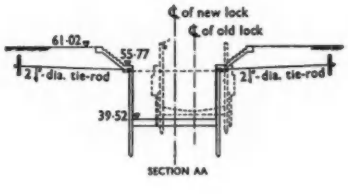


Fig. 17 (below). Cast-iron sill.

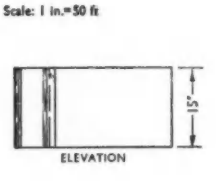
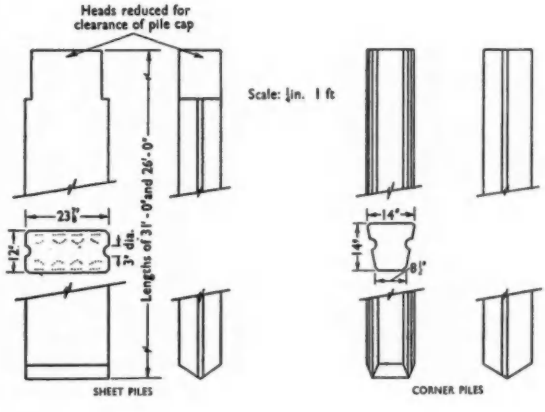
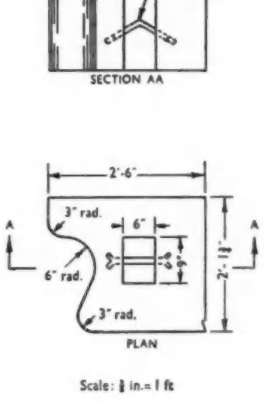
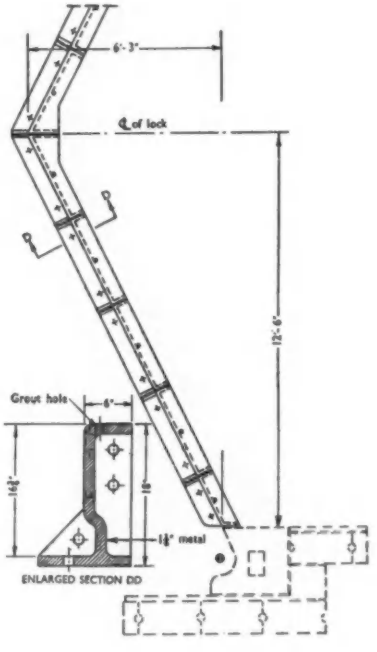


Fig. 18 (centre). Hollow quoin blocks.







The invert of the lock is mass concrete, sills (Fig. 17) are of cast iron, and the hollow quoins are built of precast blocks of high-grade concrete (Fig. 18).

Joints between all the piles are sealed by a rich cement grout poured into the 3-in. dia. grout holes already mentioned. To provide a wearing surface and protection for the prestressed piles the lock walls are finished with 2-in. of Gunite sprayed on over a wire mesh fabric secured by Rawlplugs. Vertical rubbing strips of greenheart timber are provided along the lock sides at 10-ft. centres.

The lock gates are of timber with greenheart frames and Kara Sea redwood sheeting (Fig. 19). A cast-iron shoe is fitted to the bottom of the heelposts and this swings on a cast-steel pintle set on a cast-iron seating bolted to the concrete invert (Fig. 20). The top of the heelpost is held by a mild-steel collar strap secured in a cast-iron anchor plate shaped to fit the hollow quoin and bolted down to the concrete coping. The gate shoe is set ½-in. off centre so that the heelpost swings clear of the hollow quoin as the gate opens. In the first instance the lock gates were provided with balance beams and were pushed open by hand, but a hand-operated rack-and-pinion mechanism of the strut type has since been added. These machines are readily convertible to electric operation should this be required.

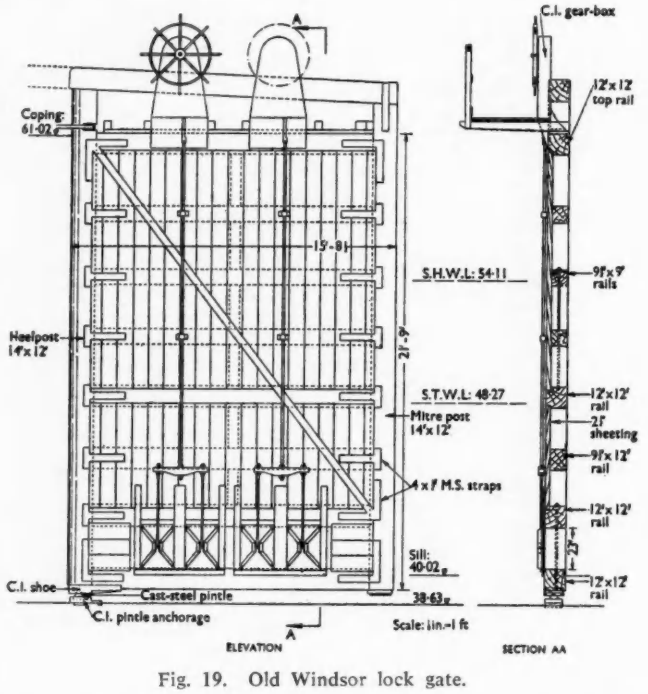


Fig. 19. Old Windsor lock gate.

Provision is made for damming off each end of the lock and de-watering should this be necessary for maintenance purposes. In this connection subsoil pressure-relief valves are provided to prevent excessive upward pressure on the underside of the invert.

(ii) Construction

Early in 1953 an order was placed for the manufacture of the prestressed concrete piles. These were delivered by road to the Conservators' depot at Sunbury where they were stored. They were subsequently taken by barge from Sunbury to the site, as called for by the contractor.

The main contract was let in June 1953 to Messrs. A. Jackaman and Sons, of Slough. The period of closure of the lock to traffic was from October 1, 1953, to March 31, 1954, but the contractor was able to start immediately on making up the road access, erecting plant, and on a certain amount of pile driving outside the limits of the existing lock. The principal item of plant was a 10-ton steam derrick on bogies, travelling up and down one side of the lock; this derrick was able to unload barges of piles as they arrived at site and pitch the piles in the leaders of the various pile frames.

The contract drawings provided for head and tail dams of steel sheet-piling to keep out the water, but they did not provide for a cofferdam round the whole site. Previous experience in general, and in particular when the old lock had been pumped out for inspection on a previous occasion, had led to the belief that no great quantity of water would be encountered, and that grouting the recesses between the concrete sheet-piles would be sufficient to keep the site reasonably dry. The contractors asked to be allowed to surround the whole site with a steel-piled cofferdam and their tendered price included for this. This modification was accepted and, in view of the amount of pumping that proved necessary, the authors accept that the contractors were right in their request in this instance.

It proved possible to drive much of the cofferdam before closing the lock to traffic on October 1. On October 21, the cofferdam was complete and pumping out started; by this time a number of concrete piles had also been driven at the tail of the lock, and the bell-mouth entrance was beginning to take shape. A sump was established near the tail end of the lock and sub-drains discharging into it were extended as excavation proceeded. At an early stage a portion of the new invert was cast around the sump and a steel tower to carry the pumps was erected on it. Just prior to the completion of the work the sump and sub-drains were sealed with concrete.

The accurate driving of the concrete sheet-piling presented the contractor with some difficulty to start with. To keep them plumb it was necessary to use two heavy timber walings, the lower at invert level and the upper at ground level; to keep the vertical edges of the piles in close contact it was necessary to restrain the leading pile by a bond around the piles already driven. Four-ton single-acting steam hammers in timber pile frames were used for driving; some of the difficulties might have been avoided by the use of heavier pile frames. The best method was only arrived at after a certain amount of trial and error, but the very accurate result in line and level, so essential for this class of work, is a tribute to the care taken by the contractor in this respect.

Pile driving continued by day; night shifts worked on demolition of the old lock and excavation of the floor to formation level. Finally, a Ransome 410, with skimmer scoop equipment, was lowered into the bottom of the lock to complete the excavation.

Concreting of the invert was put in hand on February 11, followed immediately by the positioning of the cast-iron lock-gate sills, the hollow quoins, and the Gunite facing of the lock walls. On Sunday, March 14, the tail gates were lifted into place and setting up of the sluice gear followed; the head gates were installed the following week-end. These had been built by the conservators' carpenters in the Sunbury workshops and were transported to site by barge. They proved an almost perfect fit, requiring very little adjustment on site. In the meantime, the Guniting continued with all speed and the permanent timber rubbing strips were fixed. The new lock was finally cleared of all equipment and debris and water was admitted on March 24. Cutting off the steel sheet-piles started on March 27 and by evening of March 31 both head and tail dams were removed; thus the lock was open to traffic on April 1. Concreting of the terrace steps and general clearing of the lock sides remained to be completed, and also a small quantity of Guniting to walls above water level. Outside the lock a certain amount of steel sheet-piling

protective works to the banks also remained to be done. (Fig. 21 shows the completed lock.)

The method of placing the permanent tie rods on the towpath of the lock is of some interest. The entire area on this side of the lock was obstructed by the derrick crane and its tracks, thus making it impractical to open up trenches for the tie rods. It was essential that these tie rods be fixed long before the crane could be removed, and this was done by threading each tie rod through the prepared hole in the capping beam, screwing on a conical point, and forcing the rod through the ground under the crane tracks to the anchorage pit. A Trewhella winch, with its cable secured to a clamp on the tie rod, was used to pull each tie rod forward through the ground, and although the applied pull was slightly divergent from the desired alignment, this proved entirely successful. The time required to place a tie rod was about 1 hour.

Cookham Lock

The first pound lock and the lock cut at Cookham were opened to traffic in 1830, prior to which navigation was only possible via a flash weir on what is now a weir-stream. The lock was extended at its lower end in 1892 and it continued in use until the reconstruction of 1956-57 (Fig. 22). Both gate recesses and the wing walls above the upper gates were constructed in masonry, the remainder of the lock being of concrete with masonry copings, resting on timber piling below tail-water level.

In 1952 the lock was pumped out for repairs to the timber sills of the lock gates, and the condition of the underwater timber was found to be so bad that complete reconstruction of the lock was the only satisfactory remedy. At this time it was found impossible to pump the lock completely dry without causing considerable leaching of fine material from beneath the walls. Moreover, there was very considerable inflow of water through the invert, which largely consisted of concrete bagwork, and the necessary rate of pumping was so high that work was stopped as soon as the minimum essential repairs to the sills were completed. The preparation of detail drawings for a new lock was commenced in January 1954.

(i) Design

The dimensions of the new lock are 184-ft. long between upper and lower gates, by 25-ft. wide by 8-ft. 3-in. deep on sills at standard water levels (Fig. 23). The lock carries heavy traffic in summer and therefore it was decided to install electrical operating gear. In addition to normal river traffic, Cookham Lock passes a large number of small boats, particularly at week-ends. In order to cope with this volume of small-boat traffic, three pairs of gates were installed in the new lock. This arrangement provides a short lock 65-ft. long at the upstream end, which can be used to speed up passage of small boats, and reduces the quantity of water for each lockage.

As a result of the pumping experiences of 1952, it was realised

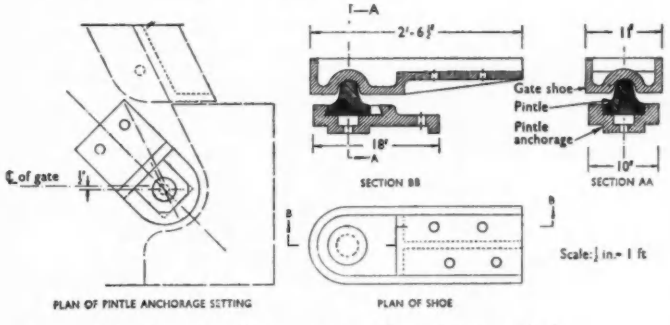


Fig. 20. Old Windsor Lock. Gate shoe and pintle.

Fig. 21. Completed Old Windsor Lock.

that the new lock would have to be constructed within a complete cofferdam; it was therefore decided to construct the lock sides as anchored steel sheet-pile walls. Above tail-water level the walls are carried up in reinforced concrete to coping levels. Larssen No. 3 section steel piling was used for the middle and lower gate recesses, the remainder of the work being in Larssen No. 2 section.

A continuous waling consisting of two 10-in. x 3½-in. x 24.46 lb. rolled steel channels is bolted to the back of the piles near the the top. 2¼-in. dia. mild-steel rods at 10-ft. 6-in. centres tie the waling back to anchorages of steel sheet-piling, the tie rods being generally 31-ft. and 34-ft. 6-in. long. Each anchorage consists of a group of three Larssen No. 2 steel sheet-piles 8-ft. long with two 9-in. x 3-in. x 17.46 lb. rolled-steel channels bolted across the back to form a waling; the tie rod passes between these channels and is secured by a 6-in. x 6-in. x ½-in. plate and nut. The tie rods are in two halves joined by a box coupling.

The invert of the lock is of 1:2:4 mass concrete keyed to the sides by a 4-in. by 4-in. by ½-in. angle welded on to the face of the steel piling. Sills and hollow quoins are formed with precast concrete blocks.

Through the body of the lock a 4-in. by 4-in. by ½-in. angle waling is bolted to the face of the piles at a level of 77.00 O.D. and above this the piles are faced with reinforced concrete with a minimum thickness of 6-in. The reinforcement of this concrete is No. 11 B.R.C. fabric located 3-in. from the front face and this is continued up to the top of the reinforced concrete cantilever wall which sits on the top of the piling. In the gate recesses this reinforced concrete facing is continuous from invert to coping level. (See Figs. 24 and 25.)

The lock gates were made in the conservators' workshops at Sunbury-on-Thames and were transported to site by barge. Greenheart framing and deal sheeting were used with ½-in. mild-steel plate for straps and fastenings. The standard cast-iron shoes pivoting on cast-steel pintles were fitted, and the mild-steel collar straps are held in cast-iron anchor plates bolted down to the concrete coping. A timber gangway with tubular steel hand-railing is provided across the top of each gate. Four sluices 1-ft. 7½-in. by 1-ft. 11-in. deep are provided in each gate, these are arranged in two pairs, each pair being fitted with mild-steel sluice gates and frames.

(ii) Machinery

Each pair of sluice gates is raised or lowered by means of a screwed rod-and-nut mechanism mounted on the top rail. There is one master unit on each gate comprising a 1 h.p. electric motor,

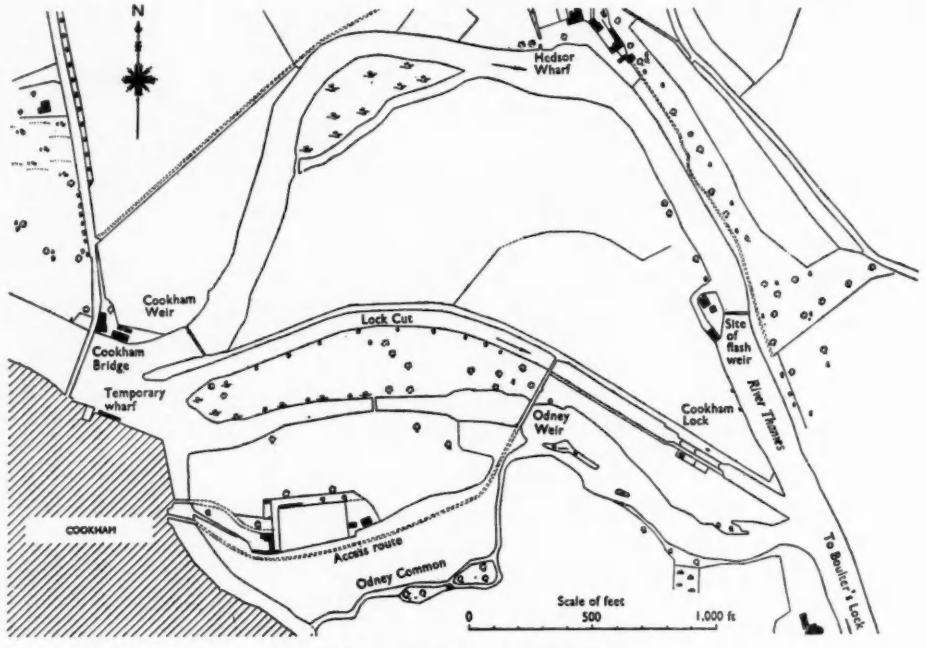


Fig. 22. Cookham Lock. Site Plan.

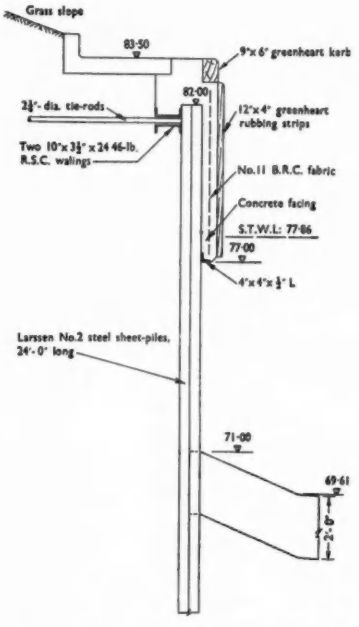


Fig. 24. Typical section of lock wall.

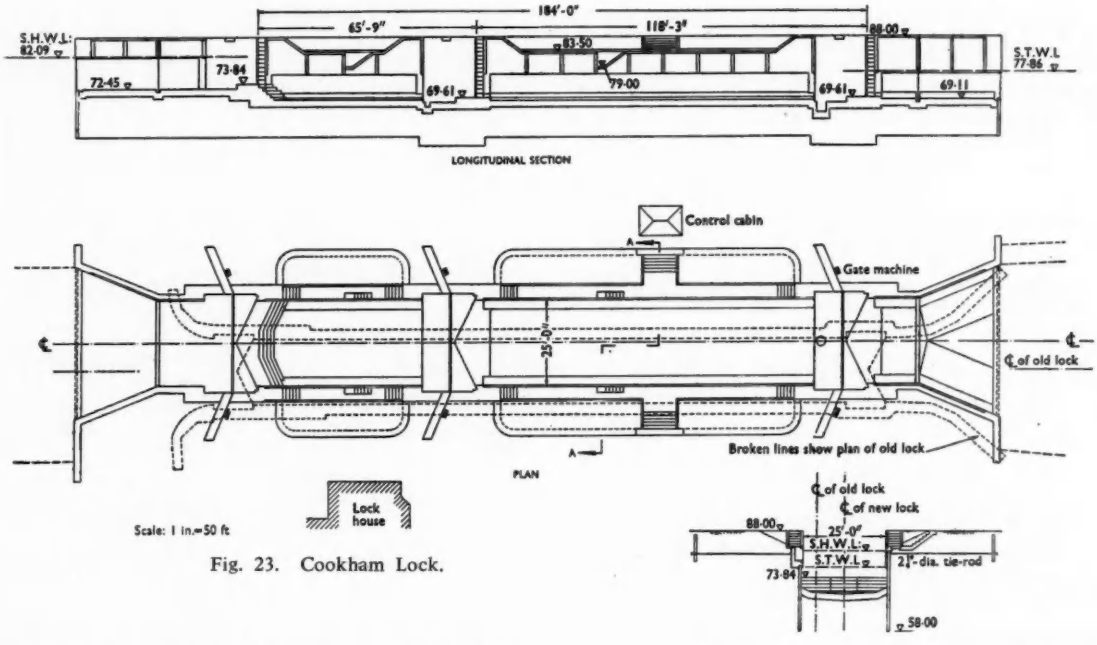


Fig. 23. Cookham Lock.

gear box, bevel gears, and a chain drive to a crank handle for manual operation. The second pair of sluices are operated by a slave unit connected to the master unit by a shaft drive with "Renold" chain couplings. In both the slave and master unit is a phosphor-bronze nut bored with an "Acme" thread of three threads per inch to suit the 1½-in. dia. mild-steel screwed rods.

The lock gate opening machines are of rack-and-pinion operated, strut type, similar to those installed at Old Windsor, but in this case electric power is provided. A vertical shaft carries the pinion and a roller bridle through which the strut passes, the rollers ensuring that the cast-iron rack is kept in correct mesh with the pinion. The vertical shaft is rotated by bevel gearing at its upper end, the drive from the motor being transmitted through a fluid coupling and a reduction gear box. A "Renold" chain drive from a crank handle allows manual operation as necessary. When not in use the crank handle folds into the machine case, this action disengaging it from the drive and also closing a safety switch in the holding circuit. The crank handle mechanism and other parts of the sluice machines are identical with those of the gate machines, thus simplifying manufacture and providing interchangeability of spares.

(iii) Electrical Equipment

The power supply is A.C., 50-c., 400-v., brought to the site by overhead lines which terminate at the lock house where a small room houses the Electricity Board's equipment, meters, and main fuses, etc. From this point a 4-core copper-sheathed mineral-insulated cable passes underground and crosses the lock, in the

bottom of the middle gate recess, to the lock keeper's office and control cabin on the far side.

Each of the six lock gate machines is fitted with a 1 h.p. totally enclosed, squirrel-cage, three-phase motor and each sluice machine has a similar type of motor, flange-mounted on a reduction gear box.

On the main control panel are twelve electro-magnetic, direct-on-line, reversing contactors—one for each motor. The panel is contained in a sheet-steel cabinet, the doors of which are connected to a safety switch which renders all circuits dead in the event of unauthorised or accidental opening. A key-operated switch mounted inside the cabinet allows the circuits to be energised for testing. At one end of the cabinet is a main isolator switch and distribution board through which the incoming power is fed. The usual overload and no-volt safeguards are provided and a thermostatically-controlled tubular heater is fitted in the base of the cabinet to keep the equipment dry.

The holding circuits are energised at 50-v. from transformers mounted in the cabinet. Three push-button panels with appropriate indicator lamps, one for each pair of gates, are mounted in convenient positions under the window overlooking the lock. A three-way selector switch energises the appropriate control desks for the use of the "upper," "lower," or whole lock as required.

Limit switches are fitted to each machine to stop the motion at each end of its travel and intermediate stops can be made by means of the emergency stop buttons on the control desks. Reference has already been made to the safety switch fitted to the crank handle mechanisms, this has "normally open" contacts which are only closed when the handle is in the parked position. By this arrangement it is impossible for the motors to be started when the machines are being manually operated, thus avoiding the risk of injury from a handle revolving at speed. To ensure correct sequence of operation of the lock some electrical interlocking is provided by means of relays mounted on the main panel. Similar relays operate the indicator lamps on the control desks.

All wiring between the control room and machines is carried out in copper-sheathed cable laid underground. Where these cables have to cross the lock, they are led down through the concrete walls in ducts formed with polythene tubing. Across the lock floor they are laid in preformed grooves and clipped down at suitable intervals.

(iv) **Construction**

Reconstruction of Cookham Lock was carried out by direct labour under the supervision of the Reading Divisional Engineer.

The period during which the lock could be closed to traffic was 6 months from October 1, 1956, to March 31, 1957. In order to ensure that the new lock would be open to traffic on time, it was decided to carry out as much work as possible during the summer of 1956 while keeping the old lock in operation.

Once the lock was closed on October 1, the piling continued rapidly. By October 29, the piling was complete round the whole site and the lock was pumped out for the first time on November 6. Installation of sub-drainage and the main sump was followed by breaking out of old concrete and masonry and excavation to the new formation level. Explosives were used for demolition of the old lock wall and although it was possible to use small charges only, this greatly speeded the work.

The concreting plant was set up on December 10 and concreting of the new invert commenced on December 12 with the placing of the tail gate recess. Flood lighting from portable generators was installed to enable longer hours to be worked, but no night shift was necessary. The reinforced concrete work above piling level was the limiting factor in the rate of progress, but all essential work was completed to time and the new lock with manual operation of the gates, was opened to traffic on April 1.

The construction plant used on site included a 3-ton electric derrick crane on bogies, one Priestman "Panther" and two Priestman "Wolf" excavators; these dealt with all the normal lifting and earth-moving tasks. The heavy work involved in handling the lock gates was dealt with by the conservators' salvage barge which is equipped with sheer-legs capable of a 10-ton lift. With this, the tail gates were placed directly into position, and the middle and upper gates were lifted over the tail dam on to the lock invert. A 3-ton tractor-mounted winch with a return block was used to drag these gates along the lock floor, on rollers, to their appropriate place where they were raised to the final vertical position by means of a 7½-ton hand crab winch mounted on a simple gantry supported on the lock walls.

No. 5 McKiernan-Terry double-acting steam hammers were used for the pile driving, a No. 6 hammer being used at one or

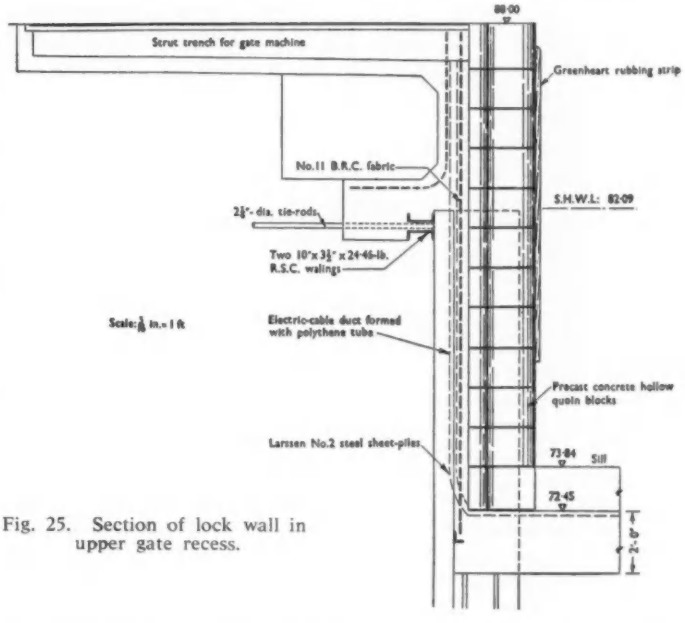


Fig. 25. Section of lock wall in upper gate recess.

two points where driving was particularly hard. A B.S.P. light mobile pile frame with a drop hammer was used for driving the anchor piles.

Three diesel-driven pumping sets were set up, comprising Sykes 6-in., 8-in., and 10-in. pumps. Under normal conditions the 8-in. pump, which was the "Univac" self-priming type, was capable of keeping the work dry. In times of high water, the 10-in. pump was necessary, and under extreme conditions the 8-in. and 10-in. pumps had to be run together. The 6-in. pump was kept as a standby in case of breakdown.

To enable plant to move from one side of the lock to the other a temporary bridge of ex-military small box-girder equipment was erected once the lock was closed.

Profiting by past experience at Old Windsor, the placing of the tie rods was mostly done by thrust boring. For this purpose, a "Mangnall" hydraulic jack was used, kindly loaned by the Metropolitan Water Board. A mandrel was driven along the line of the tie rods in the first instance and the tie rod was inserted as the mandrel was withdrawn. This method was successful. Perhaps the most interesting operation was driving four 60-ft. tie rods right under the adjacent lock house to anchorages situated

(Continued at foot of following page)

Chamber of Shipping Annual Report

Views on Administration of B.T.C. Ports

A section of the annual report of the Chamber of Shipping of the United Kingdom dealing with port facilities makes special reference to the work of the Stedeford Committee which was set up by the Minister of Transport "to examine the structure, finance and working of the organisations at present controlled by the British Transport Commission." The report points out that the committee, was in fact, an advisory group. The ports at present operating under the ownership and control of the B.T.C. comprise one-third of the port facilities in the United Kingdom.

The shipping industry welcomed the opportunity of appearing before the advisory group and of giving its views on the future administration of these ports. This was done jointly with other leading users of the ports through the Traders' Dock and Harbour Co-ordinating Committee. The general submission was made that the majority, at any rate, of the Commission's ports should be transferred to the control of port trusts on which the payers of dues should be adequately represented, together with those working in the ports.

The following specific proposals were put forward:—

A commission should be formed to take over from the B.T.C. all the ports under their control, under financial arrangements to be determined.

The new commission should be constituted on port trust lines, i.e., with the majority of members representing dues payers to be appointed by the Minister of Transport after consultation with national organisations representative of traders, owners and dock labour. The new commission should also include a full-time member with first-class experience of port operation.

It should be the duty of the new commission to transfer within a specified period of, say, five years, the ports taken over, either individually or in groups, to independent port trusts. During this interim period, the new commission should be charged with the following specific duties:—

(a) to maintain, operate and administer the existing port facilities at the docks, harbours and wharves entrusted to it;

(b) in consultation with shipowners and traders to do all that is reasonable and practicable to meet the needs of the trade of the port and to provide means of access to the ports for all forms of transport;

(c) to levy charges as would be adequate to meet working expenses plus interest and amortisation of capital and to provide proper reserves to ensure financial stability.

The report adds that the White Paper, "Re-organisation of the Nationalised Transport Undertakings" has since been published. The Government's proposal to transfer the B.T.C.'s Docks Division to a new statutory Docks Board goes some way towards meeting the proposals made to the Stedeford Committee by providing for the financing of the Commission's ports to be kept separate from the other activities of the Commission. This, it is stated, is an improvement on the present position, as it should remove the danger of port users being called upon to subsidise other services operated by the Commission. Legislation to give effect to the Government's proposals is expected to be introduced in the next session of Parliament. In the meantime, shipowners and traders will continue their efforts to bring about the transfer of the Commission's ports to independent public trusts.

On the subject of dock strikes, the Chamber report comments on the fact that delays to shipping caused by unofficial dock strikes have had to be mentioned all too often in the annual reports. In 1960, London experienced its thirteenth major unofficial stoppage of labour during the past twelve years. An unofficial strike by tally clerks in September virtually brought the port to a standstill for 28 days. This strike and those responsible for it were condemned in forthright terms in the report of the committee appointed by the Minister of Labour under the chairmanship of Mr. Hugh Lloyd Williams.

As the report stated, "an official stoppage gives a port a bad name and results in diversion of trade, some of which never returns . . . ." and there is no doubt that there is growing uneasiness among port users about the position in London. The Chamber points out that the shipping industry suffers most from stoppages of this kind and incurs greater losses than any other single interest—losses which can never be retrieved. The actual amount in terms of money is incalculable; not only is there great waste of ships' time and cargo space, but also heavy consequential expenses due to dislocation of regular services and the need to make costly adjustments of schedules.

A rough estimate of the loss to shipowners in respect of ships held up in the port during the 28 days of the strike puts the loss of ships' time alone at some £2,000,000. In addition, 196 ships destined for London were diverted elsewhere and 125 ships sailed from the port without completing loading or discharging. Moreover, delivery of tens of thousands of tons of inward London cargo had to be given at Continental ports and the charges for the additional handling, storing and eventual reshipment to London (met to only a limited extent by merchants) cost shipowners many hundreds of thousands of pounds.

The Chamber adds this comment: "Shipowners sustain the direct impact of these strikes. The consequences to the nation in general of such irresponsible action are immense. The effect on the trade of the country is most damaging and overseas markets once lost to foreign competitors may never be regained. The London Chamber of Commerce carried out a comprehensive inquiry among 51 trade associations representing users of the port and produced an interim factual report which was submitted to the Government and given wide circulation. This was of particular value in demonstrating the extent of the damage and loss caused to the national economy."

The Thames Conservancy—continued

behind it. Although the method was successful and saved a great deal of time compared with trenching, it was much slower than at Old Windsor. This was not on account of any defect in the method or mechanism, but solely because the tie rods at Cookham are at a deeper level than those at Old Windsor.

Cost of Works

The following table summarises the cost of the works described.

Site	Description of Works	Date	Total Cost
Chertsey Weir (Direct labour)	Reconstruction of existing weir and installation of 37 hand-operated radial gates.	1955	£24,229
Old Windsor Lock (Contract)	New lock 179-ft. long by 24-ft. 2-in. wide by 8-ft. 3-in. deep, in prestressed concrete sheet-piling	1953 - 54	£79,698
Cookham Lock (Direct labour)	New lock 184-ft. by 25-ft. by 8-ft. 3-in. deep in steel sheet-piling and reinforced concrete. Three pairs of electrically-operated gates.	1956 - 57	£93,534

Port of Newcastle Staff Changes

The Tyne Improvement Commissioners have announced that their General Manager, Mr. W. G. Brown will retire next August. He will be succeeded by Mr. A. J. Clarkson, at present Assistant General Manager.

Mr. V. A. Thompson, at present Assistant Treasurer, will become Treasurer on the retirement of Mr. A. V. Blunt on 11th October next.

International Quarantine*

A Review of Present Regulations

By ROBERT I. HOOD, M.D., M.P.H.
(Chief Medical Officer, International Quarantine World Health Organization)

SATURDAY morning, 23rd January, 1960, the daily epidemiological radio bulletin of the World Health Organisation, Geneva, broadcast in morse code by Radio Suisse at 0800 G.M.T., contained the words "latest information reported 21st January smallpox USSR Moscow 10."

This daily radio bulletin is one of the means used to inform health authorities about the quarantinable diseases throughout the world. Since the outbreak in Moscow was considered important new information, we first used other means of communication beginning late in the morning of Friday, 22nd January when the telegram from Moscow arrived in my office. A multiple address telegram at full rate was sent to European national health authorities, and to our quarantine units in Alexandria, Singapore and Washington. Meantime the same information was given to several health authorities who telephoned for official confirmation or otherwise of news they had picked up.

Our "Weekly Epidemiological Record" for 22nd January was already printed and being wrapped up for airmail delivery at the time the Moscow telegram arrived so this means of communication could not be used until the following week.

This is an example of international quarantine operations in 1960; but what of international quarantine in the past?

Evolution of International Quarantine

In 1348 Venetian authorities, realizing their responsibilities to prevent the importation of dangerous diseases, authorised the Overseers of Public Health to spend public money for the purpose of isolating infected persons, ships and goods at an island in the lagoon. By 1448 they had formed a complete code of quarantine regulations which served as a model for all others for over 400 years.

In England in 1603 an Act was passed for the relief and ordering of persons affected with plague within the country. Although it contained no provisions relating to maritime quarantine, its provisions evidenced a clear conception of the importance of personal infection in the spread of epidemics. Some thirty years later (1636) certain "Directions" issued by the College of Physicians followed the custom of Italy and provided for isolation in a pest-house of persons and goods for 40 days. As trade with the Levant became more extensive regulations were enacted in 1664 which, introducing Bills of Health, took cognizance of the state of health of the port of departure—and the state of health of the ship before departure—but not during the voyage. For the first time a variation of the original period of 40 days appears, goods having to be aired for only 21 days under certain circumstances.

By the time the second Quarantine Act was passed in England (1752), Parliament took notice of the fact that maritime quarantine measures were causing inconvenience and expense to the merchant because of the delayed turn-round time for vessels. This factor of interference with traffic is still with us. Airlines and especially those looking forward to an extensive use of expensive jet planes, are requesting that time-on-the-ground be reduced to a minimum by carrying out disinsectization measures in flight and reducing or speeding up measures on the ground.

Just over a hundred years ago (1848) England led the way by discontinuing the old system of universal and lengthy detention of vessels with their crews and passengers when they came from infected ports. Instead, a rational system of strict sanitary supervision of vessels and all persons on board by trained medical officers was established.

In 1851 the French Government convened the first International Sanitary Conference with the object of reaching agreement on minimum maritime quarantine requirements. Nine more international sanitary conferences were convened in the nineteenth century. They succeeded in preparing a number of limited conventions, limited because not enough was known of the methods of spread or control of diseases. However, they did lead to acceptance of international discussion as a means of dealing with health matters of interest to many countries.

At the time of the International Health Conference convened by the United Nations Economic and Social Council in 1946, some 13 international sanitary conventions and similar arrangements dating from 1903 were in force. Nearly each succeeding convention was framed in such a way that it superseded the previous convention, but due to a lack of uniform ratification the situation in 1946 was chaotic.

The International Health Conference developed an important new mechanism for rapid universal agreement on international health regulations. Under the provisions of Article 22 of the WHO Constitution a State is required within a stated period of time to "contract out" rather than "contract in" after the World Health Assembly adopts regulations.

Armed with this new mechanism and much new scientific knowledge the Organisation was in a fortunate position when it began careful preparation for a new set of international sanitary regulations to replace all existing sanitary conventions and similar arrangements. The WHO International Sanitary Regulations, adopted by the Fourth World Health Assembly in 1951 are truly a universally accepted code of quarantine practice: some 170 States and territories being bounded by them. Even Australia, Burma and Chile, major States not legally bound by the Regulations, follow their provisions in practically all respects.

W.H.O. Activities under the International Sanitary Regulations

The principal aim of the International Sanitary Regulations, administered by the World Health Organization, is to ensure the maximum security against the international spread of diseases with the minimum interference with world traffic. It is clear that as soon as further scientific advances are made, or diseases are eradicated in additional areas of the world quarantine measures should be modified or eliminated. The World Health Assembly has charged the Director-General with keeping these matters under review and to recommend changes in the Regulations. He uses various expert groups at his disposal including a special Committee on International Quarantine which meets annually to *inter alia*, review the functioning of the Regulations and their effect on international traffic, and to recommend amendments. The mechanism of "contracting out" referred to above speeds up universal application of amendments which to date have been five.

The last amendment modifying the health part of the aircraft general declaration was adopted by the Thirteenth World Health

*Paper read before the 67th Annual Conference of the Association of Public Health Inspectors at Scarborough, September, 1960.

Assembly in May, 1960. The changes made merely incorporate previous opinions of the Committee on International Quarantine adopted by previous Assemblies, and it is hoped that all countries will agree to this amendment. The amendment will enter into force on 1st January, 1961, at which time the health part of the aircraft general declaration will read as follows:

" Declaration of Health

Persons on board known to be suffering from illness other than airsickness or the effects of accidents, as well as those cases of illness disembarked during the flight.....

Any other condition on board which may lead to the spread of disease .....

Details of each disinsecting or sanitary treatment (place, date, time, method) during the flight. If no disinsecting has been carried out during the flight give details of most recent disinsecting .....

Sgd. if required .....

Crew member concerned"

The Committee on International Quarantine reports to the World Health Assembly which may adopt the report of the Committee or may reject certain parts of the report with which it is not in agreement. The Director-General appoints members from various parts of the world to serve on the Quarantine Committee, taking note of the need to make available appropriate expert advice on, *inter alia*, quarantine practice, epidemiology, international law, transport and other allied matters as required for the proper consideration of the items on the agenda of each session. He also takes note of the need to ensure continuity of thought and action and provides to the Quarantine Committee the technical co-operation and advice of appropriate expert committees and study groups of the Organization. The Committee has now met seven times and its reports, with one minor exception, have been adopted by the World Health Assembly. The interpretations of the provisions of the International Sanitary Regulations made by this Committee and subsequently adopted by the World Health Assembly, now appear as explanatory notes in the Annotated Edition of the International Sanitary Regulations published in 1957; a revised annotated edition of the International Sanitary Regulations is scheduled for publication in the Spring of 1961.

In administering the International Sanitary Regulations, the Organization employs four quarantine units: one in its Headquarters in Geneva and three others, in Alexandria, Singapore and Washington. Even though the three quarantine units outside of Geneva are part of the Organization's Regional Offices, Headquarters maintains technical supervision over their activities. Day to day administration of the Regulations in North East Africa, from Tunisia to Ethiopia and part of Asia up to Iran is carried out by the Quarantine Unit in Alexandria; the remainder of Asia is covered by the Unit in Singapore while the Americas are the responsibility of the Unit in Washington. The Unit in Geneva has direct responsibility for Europe and the rest of Africa.

If airport and port health authorities are to carry out realistically the international quarantine measures provided for in the International Sanitary Regulations, they need current information on the occurrence of the quarantinable diseases. In operating its epidemiological intelligence system as required by the Regulations, the Organization in Geneva receives information from its three Quarantine Units on conditions in their areas and directly from the health administration of Europe and the larger part of Africa as has been indicated above. It will be recalled that Article 3 of the Regulations requires each health administration to notify the Organization by telegram within 24 hours of its being informed that a local area has become an infected local area. Further, telegraphic notifications are required by Article 9, giving the number of cases of the quarantinable disease, and deaths therefrom during the previous week in each of its towns and cities adjacent to a port or an airport.

Once such towns are free of quarantinable diseases airmail reports are sent during a period of time specified in Article 6; this period of time, except for yellow fever and rodent plague, is equal to twice the incubation period of the disease. Follow-up notifications on the occurrence or absence of quarantinable disease in other areas are sent by airmail.

Now a word as to how the Organization disseminates this information as required by Article 11 of the International Sanitary Regulations. Urgent information is sent by telegram as I have related above for the outbreak of smallpox in Moscow last January. The Geneva daily epidemiological radio bulletin is broadcast over seven wavelengths beamed to cover all continents. It is in morse code at hand speed. It contains information on quarantinable diseases in towns and cities adjacent to ports and airports, on declarations of infected areas (Article 3), or declarations that an infected area has become free of infection (Article 6). In the next section information is given on quarantinable diseases in areas other than towns or cities adjacent to a port or an airport, when the disease is reported from a country where for some months or a longer period it has been absent. The last section is reserved for information on non-quarantinable diseases of international interest. During the 1957-58 influenza pandemic this section was utilized on several occasions, particularly in the early months when the new virus strain was identified in new areas of the world.

The Geneva "Weekly Epidemiological Record," airmailed to health administrations and port and airport health authorities throughout the world, was initiated by the Health Section of the League of Nations and is now in its 35th year of publication. This Record confirms and supplements information broadcast in the daily epidemiological radio bulletin. It also gives a complete list of infected areas throughout the world each week as of Thursday evening just before publication and distribution of the Record on Fridays. Further, the Record contains information on the application of the International Sanitary Regulations such as vaccination certificate requirements of countries, yellow-fever receptive areas, ports designated and approved for the issue of deratting or deratting exemption certificates, designated yellow-fever vaccinating centres, airports designated as sanitary airports or with direct transit areas as defined in the Regulations, and information on tariffs of sanitary charges made by health authorities.

Prior to April 1958, when we began to publish the infected area list in the "Weekly Epidemiological Record," quarantine officers could not always know when an infected area was free of infection, since the Record rarely indicated the receipt of negative reports. Based on the International Sanitary Regulations as amended by the additional regulations of 1955 and 1956, the following criteria are used in compiling and maintaining the infected area list. These criteria are published from time to time in the "Weekly Epidemiological Record" and were published in the issue of 8th July, 1960.

I. An area is entered in the list on receipt of information of:

(i) a declaration of infection under Article 3;

(ii) the first non-imported case of plague, cholera, yellow fever or smallpox;

(iii) plague infection among rodents on land or on craft which are part of the equipment of a port;

(iv) activity of yellow-fever virus in vertebrates other than man using the following criteria:

(a) the discovery of the specific lesions of yellow fever in the

liver of vertebrates indigenous to the area; and

(b) the isolation of yellow-fever virus from any indigenous vertebrates;

(v) an epidemic of typhus or relapsing fever (an epidemic is interpreted to mean the occurrence of two or more non-imported cases in a local area during a four-week (typhus) or a three-week (relapsing fever) period).

II. An area is deleted from the list on receipt of information as follows:

(i) if the area was declared infected (Article 3), it is deleted from the list, on receipt of a declaration under Article 6 that the area is free from infection. If information is available which indicates the area has not been free from infection during the intervals stated in Article 6, the Article 6 declaration is not published, the area remains on the list and the health administration concerned is queried as to the true situation;

(ii) if the area entered the list for reasons other than a declaration under Article 3 (see I, (ii) to (v) above), it is deleted from the list on receipt of negative weekly reports for the time intervals stated in Article 6.

It will be noted from the criteria above that negative weekly reports are now accounted for. Depending on the type of traffic with which he is dealing, the quarantine officer needs one or more weekly issues of the infected area list, with which he can tell at a glance whether or not the plane or ship or the passengers thereof have come from an infected area.

The Organization can disseminate, of course, only official information received from health administrations. News of outbreaks of quarantinable diseases from the radio or the press are used to query by telegram the health administration concerned. Countries which are slow in notifying the occurrence and the absence of quarantinable diseases cannot expect others to apply and withdraw sanitary measures on the basis of the slow notifications. Thus, on occasion, sanitary measures are applied on receipt of persistent news reports and maintained even after official notifications of absence of the disease. The Organization, including the World Health Assembly, has repeatedly urged health administrations to fulfil their obligations for prompt notifications.

It is also our duty to obtain information and be able to deny false reports such as the note in several newspapers and at least one medical journal of some 71,000 cases of smallpox in Moscow last January. This figure was of course confused with the beginning of a mass vaccination campaign in Moscow, where over six million persons were vaccinated in a period of one week. It is also our duty to know in which area of the world the several quarantinable diseases are apt to occur so that if the health administration happens to send a wrong notification, we can query the health administration before disseminating the information.

Another service to Governments, done in conjunction with our Legal Office, is to review national quarantine laws and directives and to advise health administrations when the laws are not in conformity with the International Sanitary Regulations.

Difficulties in Working of the Regulations

I should now like to discuss briefly some of the difficulties in the working of the International Sanitary Regulations in various parts of the world as reported to the Organization. It should be clearly realized that the Organization, as the administrator of the Regulations, has no authority to require the States to follow the provisions of the Regulations. It does use persuasion and in most instances this is sufficient to obtain correction of local irregularities.

Not all governments are able to report quarantinable diseases by local area on a current basis. For example, we receive each week global provisional figures on smallpox for both East and West Pakistan and on cholera for all of East Pakistan. Details come very much later, but in the meantime we have no choice but to show in our weekly infected area list all of Pakistan as infected with smallpox and all of East Pakistan as infected with cholera. In other countries, the machinery for notifications of quarantinable diseases may get rusty from disuse. Thus, from one European country, we were notified promptly of the first case of non-imported smallpox, but learned of subsequent cases, fortunately in the same area, by reading a weekly medical journal. Later we discovered that two of the persons in the Ministry, normally charged with such notifications, were on leave at the time I was reading the medical journal. When they returned from leave the subsequent cases were officially reported.

Deratting exemption certificates and deratting certificates still give rise to some difficulties. These certificates are occasionally issued by port health authorities which have not been designated by their health administration to issue such a certificate. A port quarantine officer at a subsequent port of call then has the unpleasant duty to inform the captain that the certificate which he thought was valid is, in fact, not valid. It is a pleasure to note that in so far as such difficulties are reported to the Organization, they are becoming more rare. Another difficulty with these certificates is that not all captains and not all port authorities realize that the certificate is valid for six months only, except that this period may be extended once for a period of one month for a ship proceeding to a designated and approved port, if the deratting or inspection—as the case may be—would be facilitated by the operations due to take place there. Too often, deratting exemption certificates or deratting certificates are extended beyond seven months and even after inspection, may be extended for a period of six months instead of issuing a new certificate.

States do not always limit quarantine measures to arrivals from infected local areas. One of our own staff members was isolated for five days in a country West of India on the basis that he had spent one night in Bombay, although at the time no cholera was reported within two hundred miles of that city. The staff member did not have a cholera vaccination certificate and we learned of the situation in Geneva only after the end of his isolation.

When yellow fever was reported from a south east county of Trinidad, in a forest area, a nearby country began to require yellow-fever vaccination certificate of persons coming from any part of Trinidad. As could be expected, severe disruption of trade and commerce occurred until about ten days later, when the quarantine measures were limited to arrivals from the infected local area. On occasion, countries have required cholera vaccination certificates of arrivals from West Pakistan when no cholera had been present in that part of the country. On the other hand, in November and December, 1958, when the press reported cholera in two local areas of Pakistan, many countries required all arrivals from West Pakistan to possess a cholera vaccination certificate.

When smallpox broke out in Heidelberg, Western Germany, one health administration outside Europe decided that it would consider as an infected local area all that territory within a radius of about 75 miles of Heidelberg although Heidelberg itself and the surrounding small county had their own local public health services.

Although Article 8 of the Regulations states that each health administration shall notify the Organization of the measures that it has decided to apply to arrivals from an infected local area and the withdrawal of any such measures indicating the date of application or withdrawal, not very many do so. For some time after cholera had disappeared from Thailand, countries still maintained quarantine measures in respect of cholera for arrivals from that country. In another instance, we learned that one country main-

tained quarantine measures in respect of smallpox against arrivals from the United Kingdom for six months after the last case was reported. It is clear that some health administrations have not yet learned the significance of the infected area list published each week in the "Weekly Epidemiological Record."

Some health administrations indicate to the Organization that they will require vaccination certificates under certain circumstances and apparently in practice do not always do so. Thus the German doctor, who initiated the Heidelberg outbreak and who had been visiting several parts of India, has indicated that when he entered another country for a few days before proceeding by air to Europe, no check was made on his arrival in that country for a smallpox vaccination certificate which, in fact, he did not possess.

Under the provisions of the Regulations, bills of health may not be required of any ship or aircraft. It was some years after 1952 before health authorities ceased to require this sanitary document. Even now, a bill of health is issued occasionally on request of a captain of a ship when he states that he will need the sanitary document. To the best of our knowledge no port health authorities require this document any more.

International certificates of vaccination for use under the International Sanitary Regulations should conform with the models in the Regulations and be completed in English or French, in the prescribed manner. Apparently the majority of international travellers carry proper certificates or health authorities are quite lenient in accepting vaccination certificates. Some yellow-fever receptive countries in Asia are very strict about the yellow-fever vaccination certificate. It is known that some international travellers have been isolated on arrival because the certificate was not correctly filled out even though it should have been apparent that the individual had been inoculated with yellow-fever vaccine.

Other countries make a very close check of smallpox vaccination certificates, refuse those which are not entirely correct and take the trouble to inform the Organization of the irregularity so that it may be brought to the attention of the health authorities of the area in which the certificate was issued. We have seen one smallpox vaccination certificate to which the holder added the name of a fellow air passenger since his neighbour had no smallpox vaccination certificate. His misplaced generosity, of course, did not assist his fellow passenger when they arrived at their destination.

Contrary to the provisions of Article 101 of the Regulations, some half-dozen countries still make a charge for medical examination, especially for ships. Progress in this field is quite slow in spite of repeated pressure of the Organization to have health administrations bring their local laws into conformity with the Regulations. The countries concerned appear to have difficulties in providing alternative means of financing their quarantine activities.

Future of the International Sanitary Regulations

I should like to give some of my ideas on the future of the International Sanitary Regulations and the diseases they cover. It can be expected that the few remaining States, not yet party to the Regulations will agree to become bound by them. Already several States have concluded arrangements under Article 104 whereby their territories are combined into a single territory for the purposes of some of the sanitary measures to be applied in accordance with the Regulations. This trend to facilitate the application of the Regulations will continue to the benefit of international travellers and carriers. It is doubtful that new diseases will be added to the Regulations, but on the other hand some may be dropped as I indicate below in discussing each of them.

(a) **Smallpox**

This disease will be an important one as concerns international travel for some years to come. It has repeatedly demonstrated its ability to travel and implant itself. A number of countries, some with the assistance of the Organization, are engaged in or planning for smallpox eradication campaigns. However, no changes in the smallpox provisions of the Regulations are foreseen in the near future.

(b) **Yellow Fever**

Recently reported cases of yellow fever have been nearly all non-urban cases. For over a quarter of a century, no transmission of yellow-fever virus by international passenger traffic has been found. A jungle yellow-fever wave in Central America has proceeded since 1948 from Panama to Guatemala and British Honduras. This type of yellow fever, occurring primarily in monkeys, can be expected to invade Mexico. However, extensive *Aëdes aegypti* eradication programmes in this area and in South America, have greatly reduced the danger of international spread of the disease by sea or air traffic from the Americas. In Africa, the yellow-fever situation is not well enough known to permit health authorities to judge the danger of spread. In certain parts of Asia where conditions appear to be very favourable for the development of yellow fever, the reason for absence of the disease over the years has not yet been determined.

One unpublished recent study has shown that the duration of immunity after 17D yellow-fever vaccination, is as much as 12 years. If this study is confirmed by others, it may be possible to get unanimous agreement of Governments to increase the validity of the yellow-fever vaccination certificate to nine or twelve years rather than the present six years. No other changes in the yellow-fever provisions of the Regulations are expected.

(c) **Plague**

The number of cases of plague officially reported from 1956 to June 1960 has shown a continuing downward trend. Only three ports have been involved: Bassein and Rangoon in Burma and Saigon in Vietnam; all in 1958. The last Committee on International Quarantine noted the situation and discussed proposals for amending the plague provisions of the International Sanitary Regulations; it decided against formal changes for the present. It suggested that States consider the possibility of concluding bilateral agreements to waive or relax provisions of the Regulations, for example, in relation to the production on arrival of a deratting certificate or deratting exemption certificate. The Committee, in previous meetings, had already stated that measures need not normally be taken against a local area which has been notified as infected with wild-rodent plague, unless there is evidence that the wild-rodent plague has infiltrated or is tending to infiltrate into the domestic rodent population, and thus threatens international traffic.

The majority of plague cases have been associated with wild rodents rather than domestic rodents. Rat proofing of ships is steadily increasing and more efforts are being made to keep ships continuously free of rats. Already fewer ships are being deratted and instead, after inspection, are given a deratting exemption certificate. In some parts of the world, oil tankers are exempt from producing a deratting or deratting exemption certificate. It may be that Governments will agree to change the Regulations to eliminate reference to all rodents and concentrate on rats.

(d) **Cholera**

This disease tends to be confined to parts of India and East Pakistan but after long absence from Thailand and West Pakistan it appeared in these areas. It has since disappeared again. Studies are expected to produce a recognised standard for cholera vaccine. Subsequently, a modern type field trial of the vaccine is expected to demonstrate the limits of efficiency of this vaccine. The provision of potable water to increasing numbers of the population

should be a major factor in decreasing the number of cases of cholera and lessening the danger of its spread. For the immediate future, no changes in the cholera provisions of the Regulations are foreseen.

(e) **Typhus**

This disease recently has shown little tendency to spread except in local areas of countries where it is in effect endemic. Given a reasonably normal world situation, typhus is not an actual danger in international traffic. However, one disturbing factor is the finding of insecticide resistant lice. The sanitary measures of the Regulations for this disease, as regards arrivals, concern essentially permissive dusting and are thus not a real interference with traffic. Such sanitary measures will, I believe, be less and less applied and it might be foreseen to delete them from the Regulations.

(f) **Relapsing Fever**

Since the last World War this disease has been a local problem of East Africa. Many questions about this disease remain unanswered, but in my opinion it will not be a wide international problem as long as a more or less normal world situation exists. Sanitary measures for this disease are very little used and it might be foreseen to delete them from the International Sanitary Regulations after the reasons for the continuing reservoirs such as that in Ethiopia (3,000 cases a year) are better understood.

(g) **Malaria**

The International Sanitary Convention for Aerial Navigation, 1944, dealt, *inter alia* with sanitary measures against insect vectors of malaria and other diseases. Article 105 (j) of the Regulations exempted from abrogation the disinsectization of aircraft sanitary measures of that 1944 convention and the World Health Assembly has accepted the opinion of the Committee on International Quarantine that other States, not signatories to the 1944 Convention, have certain rights in this connection. Due to widespread malaria eradication programmes and the need of countries to protect their investments in malaria eradication this disease is assuming an ever more important place among those diseases considered dangerous in international traffic. At the present time, the majority of States are of the opinion that no amendments in the Regulations should be made as regards malaria and insect vectors of this disease and others. Many States do consider that more fool-proof and less interfering methods of aircraft disinsectization need to be developed and universally adopted. The WHO Expert Committee on Insecticides met during the week of September 19th, 1960, to consider and recommend such improved methods. The Organization will continue its efforts to secure universal adoption of recommended methods.

Hydro-Pneumatic Fenders

Experiments Show High Energy Absorption

By D. NEWMAN (Hydraulics Research Station, Wallingford)

A great deal of thought and ingenuity has been given to the problem of how to bring moving ships to rest by interposing fenders of one sort or another between ship and jetty. The varieties of fenders and berthing dolphins are now so numerous and make use of such a variety of principles that designers must already have a difficult task in deciding which to employ. One is reluctant therefore to burden designers with the need to examine any other principles; yet there is one other type of fender, recently tested at the Hydraulics Research Station, that certainly merits attention.

Although the new fender has very adequate characteristics as regards its ability to bring ships to rest without imposing large forces on them, it is its effect on the behaviour of ships moored in waves that is particularly favourable.

In 1959 a description was published of some work carried out at the Hydraulics Research Station on the movement of ships moored in waves.* In this the effect of certain variables was studied, among them the stiffness of the ropes, and the stiffness of the fenders. The experiment showed that when a ship was moored against conventional, that is to say relatively stiff, fenders, the movement of the ship could be reduced either by the use of stiffer ropes, or by increasing their number. A better solution, however, was to use the same ropes but much softer fenders, because then not only was the motion minimised, but the forces between the ship and the jetty were markedly reduced. It was shown that the fenders should be so soft that the natural period of the ship when in contact with the fenders, was much longer than the period of the waves.

The experiments also showed that gravity fenders, which over the initial part of their deflection are very soft, had desirable effects on the movement of the ship. Two important features of gravity fenders, namely, long travel and low initial stiffness are also features of the new fender, which we have called the hydro-pneumatic fender.

The fender consists of an envelope of flexible material, probably fabric-reinforced rubber, roughly cylindrical in shape, closed by a dome at the top but open at the bottom. It floats upright in the water as shown in Fig. 1 with air trapped under the dome. Initially the air may be at atmospheric pressure, in which case the water-level inside is the same as that outside, but if weights hang from the bottom of the cylinder there is excess air-pressure inside and there is a difference between the water-levels inside and outside.

When the fender is compressed the force with which it reacts is a function of the excess air-pressure inside the envelope multiplied by the area in contact with the ship. As the fender is further compressed the area in contact with the ship increases until the cylinder is almost flattened; at the same time the air-pressure rises inside as the water-level is further depressed. Finally if the fender is suffciently compressed, air may escape from the bottom of the fender.

A vertical metal spine along the cylindrical part of the fender slides in a guide fixed to the jetty, and serves to locate the fender, while allowing it to rise and fall with the tide.

A model of the fender has been made, having a diameter of 1.6-in. and an overall height of 6.6-in. It is looked upon as a

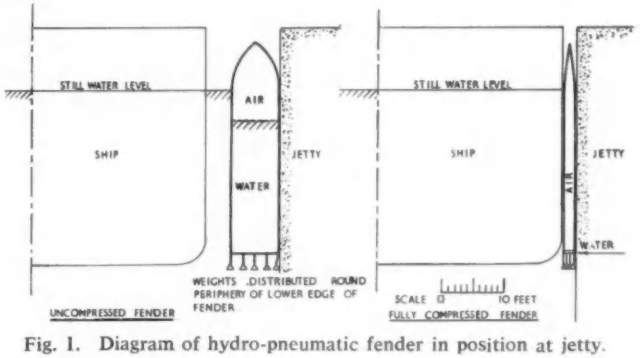


Fig. 1. Diagram of hydro-pneumatic fender in position at jetty.

1:60 model of a fender 8-ft. in diameter and 33-ft. high. The load-deflection characteristics obtained under test are shown in Fig. 2 and reveal that slightly different characteristics can be obtained by altering the initial volume of air in the cylinder and by varying the weights round the base of the fender, so that the depth of flotation remains constant.

The stiffness of a prototype fender is shown by a broken line. It is a fender in which the initial difference in water-levels is 10-ft., i.e. model D=2-in. It will be seen that the characteristics follow that of the model fender for small deflections, that thereafter the fender is somewhat softer; but, when air has been released, model and prototype correspond again exactly. The divergence arises because in the model the compressibility of the air is unimportant, whereas in the prototype the change in volume

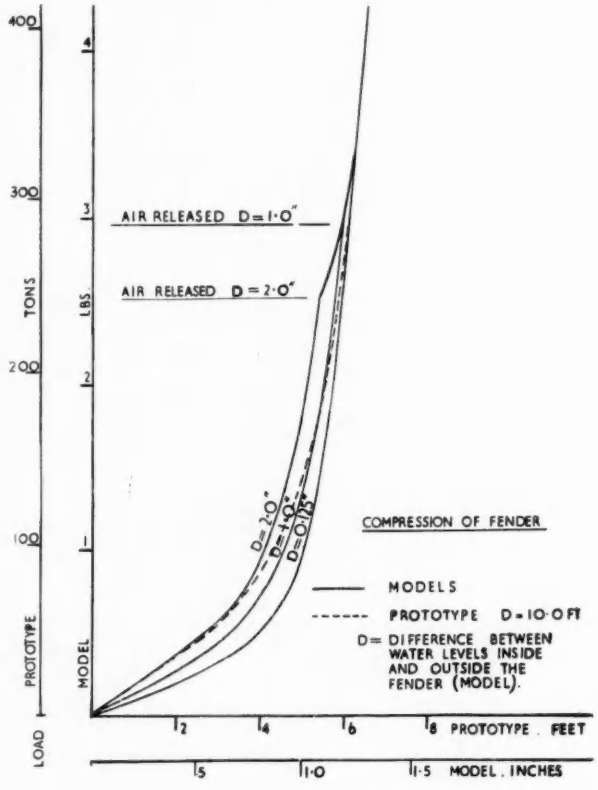


Fig. 2. Load compression curves for hydro-pneumatic fender.

of the trapped air is significant. It is impossible to predict precisely the characteristic of the prototype without knowing to what extent the compression of the air will be adiabatic and to what extent it will be isothermal.

The behaviour of a ship moved by waves while moored against the new fender was studied in a model. The model has been described elsewhere.* The model ship was a section of a 32,000 ton d.w. tanker; there were long waves the equivalent of .88-ft. high, and the model was moored with ropes of seven different stiffnesses.

Fig. 3 shows that over the great range of rope stiffness employed, (the stiffest was 50 times as stiff as the softest) the horizontal movements were consistently small around 2½-ft. For comparison is shown the much greater movement of the model obtained when elastic fenders of more conventional stiffness were substituted for the hydro-pneumatic fender.

In Fig. 4 the corresponding forces between the ship and the jetty are plotted and show an even greater advantage in favour of the hydro-pneumatic fender. The forces are seen to differ by a factor of about 10.

Energy Absorption

The energy absorption of one fender, calculated from the area under the broken line in Fig. 2 is 743-ft tons. This is the kinetic energy of a 32,000 ton d.w. tanker, having a displacement of 48,000 tons travelling at 1.0-ft/sec.

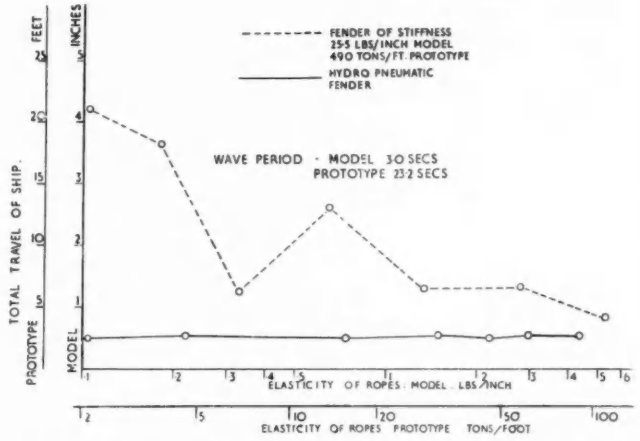

FENDER OF STIFFNESS 25·5 LBS/INCH MODEL 490 TONS/FT. PROTOTYPE
HYDRO PNEUMATIC FENDER
WAVE PERIOD - MODEL 3·0 SECS PROTOTYPE 23·2 SECS
TOTAL TRAVEL OF SHIP.
PROTOTYPE FEET
MODEL INCHES
ELASTICITY OF ROPES - MODEL - LBS/INCH
ELASTICITY OF ROPES PROTOTYPE TONS/FOOT

Fig. 3 Total travel of 32,000-ton tanker plotted as a function of rope elasticity.

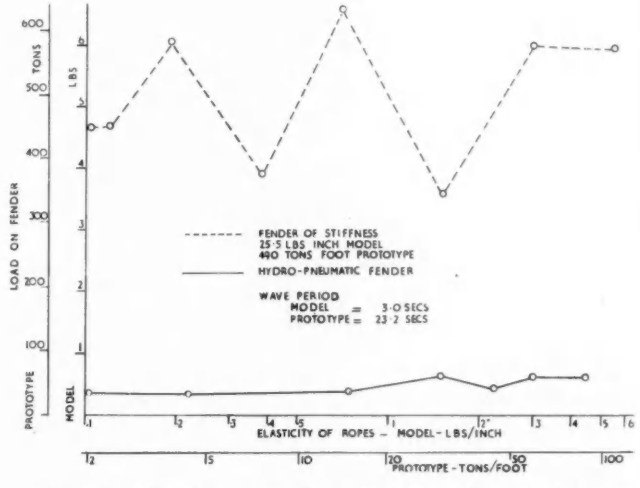

FENDER OF STIFFNESS 25·5 LBS INCH MODEL 490 TONS FOOT PROTOTYPE
HYDRO-PNEUMATIC FENDER
WAVE PERIOD MODEL = 3·0 SECS PROTOTYPE = 23·2 SECS
LOAD ON FENDER
PROTOTYPE TONS
MODEL LBS
ELASTICITY OF ROPES - MODEL - LBS/INCH
PROTOTYPE - TONS/FOOT

Fig. 4. Load on fender plotted as a function of rope elasticity.

Practical Problems

An attempt has been made to predict how the fenders will behave in practice by berthing radio-controlled models against them, and so far no difficulties have appeared. It is now our intention to have a fender made that is intermediate in size between the model one and one suitable for super-tankers; firstly in order to study further the practical difficulties, and secondly in order to get an assessment of the cost of these fenders.

Acknowledgements

The work described was carried out at the Hydraulics Research Station, Wallingford, and this article is published with the permission of the Director.

* "A Study of the Movement of Moored Ships subjected to Wave Action" by R. C. H. Russell. Proc. Inst. Civ. Engineers Vol. 12 pp. 379-398, April 1959.

The Principle of Effective Stress applied to the Problem of Lateral Earth Pressure

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Synopsis.

In this paper the principle of effective stress is applied to the problem of lateral earth pressure. It is shown how the pore pressure distribution above the ground water table should be used in computing lateral earth pressures. The analysis is applied to several illustrative cases of cohesionless material at various degrees of saturation. The strength of clays is discussed to some extent and it is proposed to base earth pressure computations of such materials on a more realistic strength envelope.

Introduction.

A soil mass, laterally restrained by a structure will apply to it stresses whose distribution, magnitude and direction depend, in general, upon the mechanical properties of the two bodies in contact. More specifically, the stresses acting across the contact surface will depend upon the stress-strain characteristics of the two materials and their relative friction coefficient.

One of the most commonly used methods of evaluating these lateral stresses consists in the application of Rankine's well known theory of limiting states of plastic equilibrium. According to it, the ratio of the major and minor principal stresses, acting on a soil element, cannot exceed a certain value which depends upon the strength characteristics of the soil in question. Whether or not this limiting value is reached depends upon the deformations which the soil element is allowed to undergo, clearly a function of the yield of the retaining structure. Granted a sufficient amount of yield, the limiting stress ratio will depend on the strength characteristics of the soil.

The Principle of Effective Stress

The principle of effective stress postulates that the volume change, the shear deformation and the strength of a soil element is determined by the difference between the total stresses acting on the element and the hydrostatic pressure acting in the fluid filling its pore space.

The validity of the principle has been amply verified for fully saturated soils, and is formulated in the well-known expression:

$$\sigma' = \sigma - U_w \tag{1}$$

where:

σ' : effective stress
σ : total stress
U_w : pore water pressure

In a partly saturated soil, the pore fluid consists of water and air, in a proportion determined by the degree of saturation. For this case, the equation of the effective stress can be expressed, approximately, as follows (Alpan, *1959*):

$$\sigma' = \sigma - U_a - S_w (U_w - U_a) \tag{2}$$

where:

σ' : effective stress
σ : total stress
U_a : pore air pressure
U_w : pore water pressure
S_w : degree of saturation

For full saturation ($S_w = 1$) equation (2) obviously becomes identical with equation (1).

Lateral Earth Pressure.

In applying the principle of effective stress to the problem of lateral earth pressures, as analysed by Rankine, it follows that the limiting ratio will be that of the principal effective stresses since it is these which govern the strength of a soil.

Consider the simple case of a vertical retaining wall, backfilled by a granular material, and having the ground water level at the horizontal ground surface.

For such a case, the limiting ratio is (Terzaghi-Peck, *1948* p. 139):

$$\frac{\sigma_1'}{\sigma_3'} = \tan^2\left(45 + \frac{\phi'}{2}\right) = N_\phi \tag{3}$$

where:

σ_1' : major principal effective stress
σ_3' : minor " " "
ϕ' : angle of shearing resistance in terms of effective stresses.

In the so-called active case, the retaining wall is supposed to have tilted sufficiently to make σ_3' the horizontal stress, whereas σ_1' is the effective overburden at a point Z below ground level:

$$\sigma_1' = \sigma - U_w = \gamma_t Z - \gamma_w Z = (\gamma_t - \gamma_w) Z \tag{4}$$

where:

γ_t : total unit weight of saturated soil
γ_w : unit weight of water

Consider now the case of the ground water level below ground surface, at depth h. The major principal effective stress acting at any depth $Z < h$ is customarily taken to be $\gamma_t Z$ without considering the state of stress in the water filling (wholly or partially) the pores of the soil above ground water level. This procedure is obviously unjustified for the reasons discussed below.

Above ground water level, at which the p.w.p. is atmospheric (i.e. datum zero) water is held in the pores by capillary forces and is in tension (i.e. at less than atmospheric pressure). Part of this zone is saturated as can be illustrated by the approximate formula (Terzaghi-Peck, *1948*, p. 116):

$$h_c = \frac{C}{e D_{10}} \tag{5}$$

where:

h_c : height of capillary rise
e : void ratio of soil
D_{10} : Hazen's effective diameter
C : constant, varying between 0·1 and 0·5 (cm²)

Thus, granular soil having $e = 0{\cdot}35$; $D_{10} = 0{\cdot}06$ mm. and taking $C = 0{\cdot}3$ would be saturated up to a height of $h_c = 140$ cm. above G.W.L.

The tension in the pore water at this point is $U_w = -h_c \gamma_w$. Above the saturated zone water occurs in a continuous phase even in the so-called pendular stage (Keen, *1931*) since the soil grains are always covered at least with a continuous moisture film. Hence, the water at any point above the G.W.L. may be considered to be in contact with the ground water. Since we are considering equilibrium conditions, the water at any point above G.W.L. is in a state of tension given by the equation (Coleman, Croney, *1952*):

$$U_w = -h \cdot \gamma_w \tag{6}$$

where:

h : height above G.W.L. of point considered.

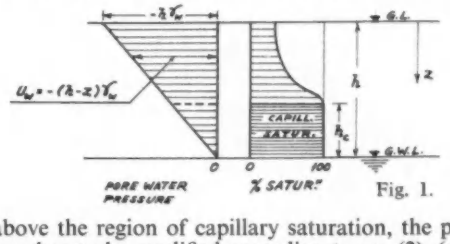

Fig. 1.

However, above the region of capillary saturation, the principle of effective stress has to be modified according to eq. (2), (see Fig. 1).

It follows that at any point below ground surface the vertical effective stress will be given by the equation:

$$\sigma_1' = \gamma_t \cdot Z - U_a - S_w [-(h - Z)\gamma_w - U_a] \tag{7}$$

In the saturated region (above and below G.W.L.) $U_a = 0$ since there is no air present and $S_w = 1$; hence:

$$\sigma_1' = \gamma_t Z + (h - Z)\gamma_w \tag{8}$$

where:

h is the distance from G.L. to G.W.L.

At G.W.L. $\sigma_1' = \gamma_t Z$ and below G.W.L. (i.e. $Z > h$)

$\sigma_1' = \gamma_t Z - (Z - h)\gamma_w$, both familiar results.

Above the saturated region the pore air pressure as well as the degree of saturation should be considered. The assumption that pore air is at atmospheric pressure is questionable in the light of recent experimental evidence (Alpan, *1959*) and should only be accepted as a gross approximation if no data are available. The degree of saturation can be easily determined, but requires, among others, information on the density of the soil. In sandy material in the field this may prove difficult and in such a case a typical (suction)/(degree of saturation) curve may prove a useful substitute (see Fig. 2: Aitchison and Donald, *1956*; Donald, *1956*); since the tension in the pore water is given by the height above the G.W.L. the corresponding S_w can be read off from the curve, account being taken of the hysteresis effect.

Once the vertical principal effective stress has been found, the minor principal effective stress, i.e. the lateral stress acting on the retaining structure, is found from the strength characteristics of the soil, as given e.g. by eq. (3).

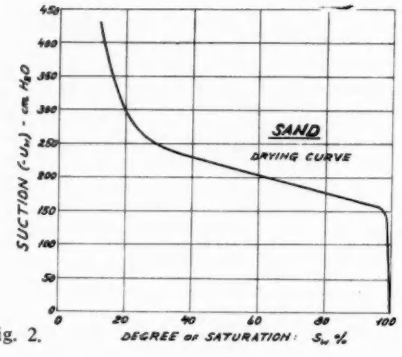

Fig. 2.

Illustration: Fully Saturated Sand.

The analysis presented so far will now be applied to a simple case and the results compared with those of the conventional approach.

Consider the case where the G.W.L. is sufficiently shallow for the capillary region above it to be fully saturated. The soil is a sand having a strength envelope of the form:

$$S = \sigma_n' \tan \phi' \tag{9}$$

where:

S : shearing strength
σ_n' : effective stress acting normal to the failure plane
ϕ' : angle of shearing resistance

In the region above G.W.L. (the only one to be considered here for comparative purposes) the major principal effective stress will be given by eq. (8). At any depth below G.L. the minimum principal effective stress cannot be less than $-U_w$ (see eq. 1), i.e.

$$\text{min. } \sigma_3' = (h - Z)\gamma_w \text{ (from eq. 8)}$$

The stress condition at a point of contact of the sand with the retaining wall at a depth $Z < h$ may be represented by a Mohr circle, whose diameter (the deviator stress) equals $\gamma_t Z$ as shown in Fig. 3. Above a certain depth, $Z < Z_0$, the value of σ_3' is too large for such a circle to become tangent to the strength envelope as illustrated by circle A. Only below the "limiting depth", Z_0, is σ_3' greater than the effective stress due to pore water tension since only then has the sand reached the limit condition imposed by its strength characteristics.

For $Z < Z_0$ then:

$$\sigma_1' = \gamma_t Z + (h - Z)\gamma_w$$
$$\sigma_3' = (h - Z)\gamma_w$$

At the limit:

$$\frac{\sigma_1'}{\sigma_3'} = 1 + \frac{\gamma_t Z_0}{\gamma_w (h - Z_0)} = N_\phi \tag{10}$$

whence:

$$Z_0 = \frac{(N_\phi - 1)\gamma_w h}{\gamma_t + (N_\phi - 1)\gamma_w} \tag{11}$$

For $Z > Z_0$ the pressure exerted on the retaining wall σ_r' will be the difference between the minor principal effective stress and the effective stress due to tension, i.e.:

$$\sigma_r' = \sigma_3' - \gamma_w (h - Z) \tag{12}$$

Now,

$$\sigma_3' = \frac{\sigma_1'}{N_\phi} = \frac{1}{N_\phi}\left[\gamma_t Z + (h - Z)\gamma_w\right] \tag{13}$$

Introducing eq. (13) into eq. (12):

$$\sigma_r' = \gamma_w (h - Z)\left[\frac{1}{N_\phi} - 1\right] + \frac{\gamma_t Z}{N_\phi} \tag{14}$$

At G.W.L. : $Z = h$, hence, from eq. (14):

$$\sigma_r' = \frac{\gamma_t h}{N_\phi}, \text{ as expected.}$$

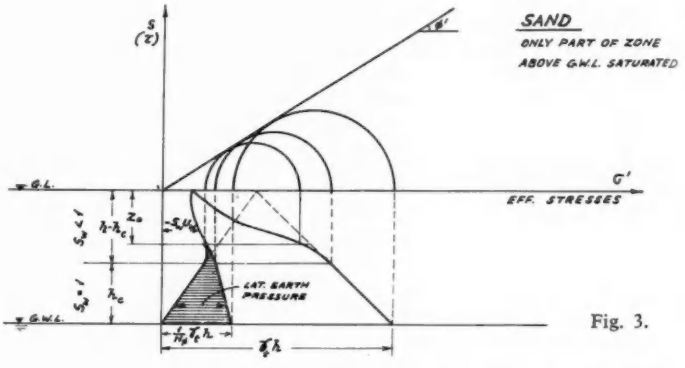

Fig. 3.

Assuming the usual triangular distribution, and remembering that σ_r' acts only over the height $h - Z_0$ of the retaining wall, the lateral earth pressure can be computed:
From eq. (11):

$$h - Z_0 = h\left[1 - \frac{(N_\phi - 1)\gamma_w}{\gamma_t + (N_\phi - 1)\gamma_w}\right] \tag{15}$$

$$E = \frac{1}{2}\frac{\gamma_t \cdot h}{N_\phi} \cdot (h - Z_0) \tag{16}$$

Introducing eq. (15) into eq. (16):

$$E = \frac{1}{2}\gamma_t h^2 \cdot \frac{1}{N_\phi}\left[1 - \frac{(N_\phi - 1)\gamma_w}{\gamma_t + (N_\phi - 1)\gamma_w}\right] \tag{17}$$

The conventional approach would furnish the following value:

$$E_c = \frac{1}{2}\gamma_t h^2 \frac{1}{N_\phi} \tag{18}$$

Comparing eqs. (17) and (18):

$$\frac{E}{E_c} = 1 - \frac{(N_\phi - 1)\gamma_w}{\gamma_t + (N_\phi - 1)\gamma_w} \tag{19}$$

Consider a typical uniform sand:

$\gamma_t = 2{\cdot}1$ gr/cm^3
$e = 0{\cdot}51$
$N_\phi = 4{\cdot}6$ (for $\phi = 40^0$)
$\frac{E}{E_c} = 0{\cdot}37$

and $Z_0 = 0{\cdot}63\,h$

Illustration: Partly Saturated Sand.

For this case, the generalised equation (2) is applicable above the capillary saturation zone. An assumption as to the magnitude of U_a must be made and, for the purpose of this illustration, the pore air pressure will be taken as atmospheric, i.e. $U_a = 0$. Eq. (2) then becomes:

$$\sigma' = \sigma - S_w U_w \tag{20}$$

In Fig. 1 the variation of the degree of saturation with height above the water table is shown; as mentioned before, the variation of U_w is linear with height, hence the major principal effective stress, according to eq. (7), will be:

$$\sigma_1' = \gamma_t Z + S_w (h - Z) \gamma_w \tag{21}$$

where:

$$S_w (Z) < 1 \text{ for } 0 \leqslant Z < h - h_c$$
$$S_w = 1 \text{ for } Z \geqslant h - h_c$$

It would be too cumbersome to try and express mathematically S_w as a function of Z and the best course would seem to work graphically by utilizing the U_w — and S_w — distributions as shown in Fig. 1. Fig. 4 is analogous to Fig. 3.

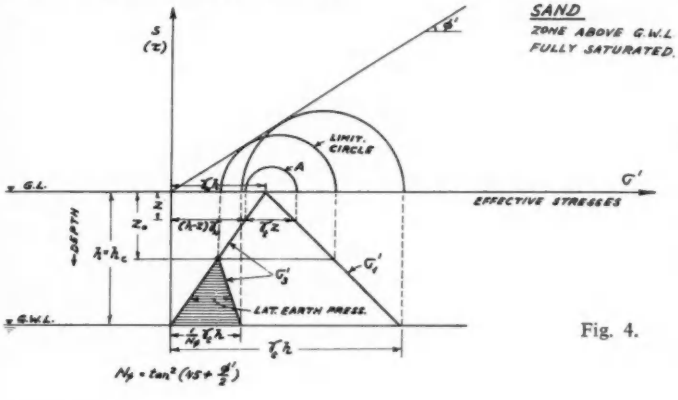

Fig. 4.

Cohesive Soils.

It should be remembered that the analysis presented above is based on the strength properties of soil in terms of effective stresses. Hence, a knowledge of pore pressures is required. In clays, partial saturation occurs only in exceptional cases but even saturated clays often exhibit very large pore water tensions, the measurement of which presents considerable technical difficulties.

In normally consolidated clays, however, pore water tensions are small. Such clays exhibit a strength envelope passing through the origin, i.e. of the form $S = \sigma_n' \tan \phi'$ and should the elevation of the water table be known, the analysis of lateral pressure in such clays would follow the lines of that for saturated sands.

The treatment of overconsolidated clays, even if saturated, presents difficulties. Irrespective of the cause of over-consolidation (whether large overburdens in the past or desiccation) the result is a saturated clay at a lower water content than in its normally consolidated past. Often the G.W.L. cannot be ascertained and, hence, the pore water pressures must be determined in the laboratory. It is quite probable that the pore water in such clays is under considerable tension, impossible to measure with conventional techniques.

The Mohr circles at failure, obtained for such clays in terms of effective stresses, can be assumed to lie too near the origin (in the conventional co-ordinate system) and to furnish a much larger cohesion intercept than would be obtained by adequate testing. It is well established, however, that the effect of overconsolidation produces a deviation of the strength envelope from the straight line passing through the origin which characterises normally consolidated clays as illustrated by point P in Fig. 5 (Gibson, *1953*).

In the following a tentative analysis will be presented for the case of a fairly soft, overconsolidated clay, whose pore water pressures could be taken as reliably measured in the laboratory. Let us assume that a cohesion intercept was found, as shown in Fig. 5. In order to ascertain whether there is true cohesion, i.e. whether the clay possesses strength at no effective stress, it would be necessary to run triaxial tests which would have a very low value of σ_3' at failure. However, experience shows that at low cell pressures the Mohr circle shifts at failure to the right (Skempton and Bishop, *1954*, p. 459). Hence it can be said that a strength envelope, established by triaxial shear tests, has a cohesion intercept if the test results for a certain range of effective stresses are extrapolated.

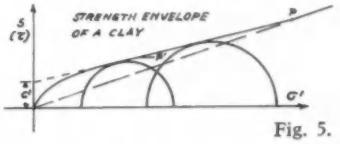

Fig. 5.

There is no reason to suppose that a particulate material such as clay should be able to withstand effective tension, an obvious implication from the existence of true cohesion. Thus a strength envelope passing through the origin seems a realistic assumption and is shown in Fig. 5.

If such a material acts upon a retaining wall then, if the G.W.L. is taken at G.L. for simplicity's sake, there will always be a horizontal pressure applied to the wall and no portion of the clay will be able to stand free, as ordinarily deduced from the existence of cohesion.

Fig. 6a shows the strength envelope of the clay considered: the circles to the right of circle (0) are tangent to the straight line $s = c' + \sigma' \tan \phi'$. At a depth Z_1 below G.L. the lateral earth pressure will be given by the relation:

$$(\sigma_3')_1 = \frac{1}{N_\phi} \gamma Z_1 - \frac{2c'}{\sqrt{N_\phi}} \tag{22}$$

where $\gamma = \gamma_t - \gamma_w$ since we assumed G.W.L. at G.L.
The circle (0) is the limiting case: the experimental Mohr circle nearest to the origin. The corresponding depth is found by equating the major effective principal stress with the effective overburden:

$$\gamma Z_0 = (\sigma_1')_0 \tag{23}$$

and the lateral earth pressure $(\sigma_3')_0$ by replacing Z with Z_0 in eq. (22).

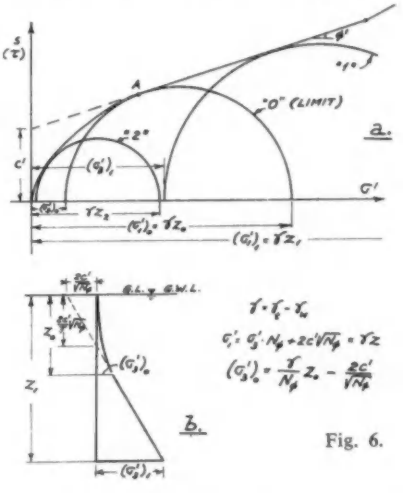

Fig. 6.

In the absence of experimental data, the remaining portion of the strength envelope may be assumed to have parabolic shape, to pass through the origin and to be tangent to the straight line at A.

In drawing a few circles, such as circle (2), tangent to this portion of the strength envelope, the lateral earth pressures at various depths can be found and the pressure distribution completed to ground level as shown in Fig. 6b. It is seen that the retaining wall is subjected to lateral earth pressures throughout its entire height, a result intuitively plausible for soft clays.

Conclusions.

The problem of lateral earth pressures on a smooth wall has been examined by introducing the principle of effective stress into the approach based on Rankine's theory of limiting states.

The distribution of pore pressures above G.W.L. was investigated and shown to influence considerably the results for sands. The effective strength envelope for clay was discussed and a more realistic evaluation of the lateral pressure of soft clays suggested.

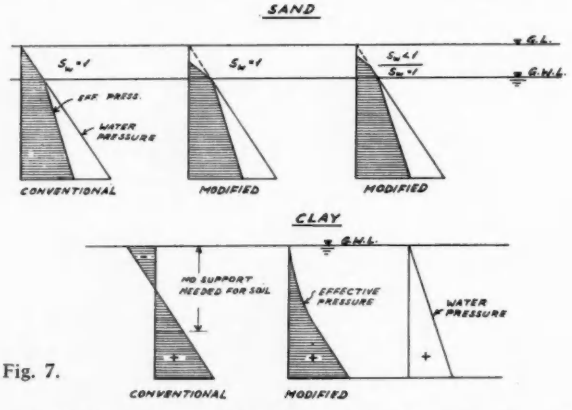

Fig. 7.

Fig. 7 illustrates the points discussed in this paper by showing the distribution of lateral earth pressure for the various cases mentioned.

It appears that, for sands, the conventional analysis furnishes safe results. It is otherwise, however, for clays particularly in the case of the design of shallow retaining structures.

Acknowledgement.

The author wishes to express here his appreciation of the stimulating criticism and comments of the present paper, offered by Professor J. G. Zeitlen and Dr. G. Wiseman of the Israel Institute of Technology.

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Modern Diving Methods

Review of Recent Technical Developments

(We published in the December 1960 issue of this Journal an article by Captain W. O. Shelford, R.N. (Retd.) on "The Work of a Diver in Harbour Waters." The article printed below, which was first published in the November 1960 issue of "Shipbuilding Equipment," forms a useful corollary to this.)

While the greater proportion of commercial diving is still carried on with equipment of a pattern designed at the beginning of the century a new, more mobile, diver is beginning to make his presence felt.

The conventional or standard diver often tends to have a conservative approach to problems and a preference for established methods, procedures or drills. The modern diver however tends to be more flexible in his approach to problems and generally has the ability to apply up-to-date scientific knowledge for their resolution.

The shipbuilder, owner or repairer, being actively concerned with the saving of time and money, should therefore be aware of the capabilities of the new type of diver.

The diver and his personal equipment

Essentially a diver is a man so trained and accustomed to the use of protective clothing and breathing apparatus that he is able to ignore this impedimenta and to carry out whatever work he is qualified to do with a facility equal to that of a workman ashore—the ability to dive is no virtue in itself.

Breathing equipment must be able to give as much clean, cool breathable gas as is required, without appreciable effort on the part of the diver, and to permit little more excess of CO_2 to accumulate than occurring in the atmosphere. Furthermore the gas supply must not be so complex an arrangement that it limits the diver's activities with heavy cylinders and cumbersome low pressure pipe line, any air supply line, in fact, should be able to double as the very necessary lifeline. Finally the diver should not depend entirely on the correct functioning of any mechanical valve for his air line supply although, up to the present, no apparatus is available which gives the diver an efficient emergency reserve.

To ensure the utmost mobility the modern diver will wear a watertight, lightweight suit of a very tough, proofed synthetic fibre over a foamed plastic suit which insulates him against the rapid heat loss which normally occurs in water.

The diver so dressed and wearing fins, to increase his ability to move easily, will be wearing little more impedimenta, nor weigh appreciably more, than a surface worker on a cold day. In this manner he will be just neutrally buoyant.

An R.F.D. inflatable dinghy used as a diving boat and fitted for survey work in mid-English Channel and equipped with Decca Navigator Track Plotter, Ferrograph echo-sounder and Magneto-meter in addition to the normal diving gear. All were transported to the launching site in one vehicle.

Where there is a stable platform available, as is normal in ship repair work, entirely self-contained gear, in which the whole gas supply is carried by the diver, will seldom be needed. With a diver who operates in this way the diving boat, if required, will invariably be of the inflatable type and carried in the same vehicle as the diver, his equipment and compressor. Inflated on site the boat will probably have an outboard engine clamped on to it after it has been dropped into the water from the dockside.

Communications are often vital and recorder/telephone equipment will be carried, this gives the diver clear communication with his attendant in the boat or, if he is working single-handed, allows him to record his survey observations.

The diver's work invariably begins with a survey to find out what has to be done and to assess the various means of doing it and, as visibility underwater in ports and docks is generally nil, he has to rely on his sense of touch. Water is a particularly effective medium for the operation of ultrasonic apparatus which can be used to detect flaws such as the end of a fracture in a plate. It is also an excellent medium in which to handle radioactive materials and thus take radiographs of otherwise inaccessible parts of a structure.

Where visibility of an inch or more is available then closed circuit television or simply photography may be used. The former, with the camera handled by the driver to instructions given from the surface, gives an instantaneous picture on any number of screens but, for many jobs, may be too expensive. In this case photographs made on the hand principle can be used, these give a good positive print, fully developed, just one minute after releasing the shutter. Such photographs are useful adjuncts to a survey report.

The foregoing methods apply at this time. It has however been found possible to generate acoustic frequencies, through water, having the wavelength of visible light which will, if it can be focussed and manipulated, give fine definition. This control has apparently been reached by Russian scientists, in the laboratory, but it is not yet commercially applicable.

A Fi-Cord tape recorder, with diver's microphone and headphones, in an underwater case.

The diver's capabilities and methods

Although often hampered by having to rely on touch rather than sight, a much keener sense, the diver has a greater potential than the surface worker. He does not have to support his own weight and, using properly designed tools which are also almost weightless, his ability to 'float' up and down the surface of a rudder or around the blades of a propeller, without the staging required by a drydock workman, or to swim the length of a ship's bottom, unobstructed by blocks, are valuable attributes.

Water pressure also is helpful, a blank placed over a 6-in. diameter aperture 10-ft. below the surface is held in position by a pressure of approximately 140 lb., which is not inconsiderable when transferred to a narrow strip of sealing material.

To date it has been impossible to make an underwater weld that would bear inspection or pass a Lloyd's surveyor. This is a principle and urgent problem which fortunately seems capable of early resolution by using a combination of heat insulating and induction welding techniques.

A Bell Howell camera in waterproof case.

The use of shaped explosives for the cutting of metal sheets is advancing and will shortly be available as an economic method of trimming distorted or awkward plates, even in the close proximity of comparatively delicate fitting. The past difficulties of retaining the shape and flexibility of the charge, and of the lining material which actually does the cutting like a knife, within small tolerances, appear to have been overcome and the method is practical and fast.

The flame cutting of steel underwater is now a well developed technique used by most companies employed in diving. The two main methods employed use either oxy-hydrogen or oxy-arc, of these the latter has the advantage of using only one gas while the necessary generator can also be used for welding.

With the increasing use of plastic coatings and anti-corrosion systems, such as Toxion, time between dockings can be extended with intermediate dry-docking only occurring on occasions of major work such as the replacement of a tail shaft or withdrawal of a stabiliser fin. In this manner heavy expense and delays can be considerably reduced.

Ship design and ease of repair

While it can readily be seen that modern materials and techniques can keep a ship, under normal conditions, out of the dry dock for a considerable period of time the possibility of a vessel being forced to dock for a comparatively minor purpose, because the possibility of certain repair and maintenance work being undertaken with the vessel afloat was never considered at the design stage, must be faced. For example, the renewal of stern gland packings while afloat appears a makeshift manoeuvre; however, if the design were such that the rope guard could be easily removed and a larger sealing gland fitted during the repacking then the operation would become a routine matter. Similarly, a set of blanks or sealing covers to fit the underwater apertures of a ship could readily be supplied by the builder, as part of the vessel's outfit, and would substantially reduce the difficulty of a repair to a skin fitting.

Obviously, to make the fullest use of a design which allows the outside of a ship to be maintained and every job, from changing a propeller to repairing a hull valve, to be done with the ship afloat anywhere in the world means also that divers of adequate skill must be available. With the great increase of the lighter type of diving as a sport it is perhaps not unreasonable to consider the possibility of deck officers qualifying in the use of this type of gear. A further point worthy of consideration is the value of surface supplied diving equipment as fire-fighting equipment, although the converse seldom applies, and that a set or two kept aboard might prove a good insurance.

A Pye underwater TV camera.

Thus naval architects and marine surveyors, by appreciating the capabilities and mobility of the modern type of diver, can substantially help towards keeping a ship afloat from her launch to the moment of her being broken up at the end of an uneventful career. Major damage caused by collision, stranding and the like must of course be excepted from this thesis although, in many cases, it is the ability of the diver which has made the return of such a casualty to dock a possibility.

The diver's other activities

The survey and repair of ships is only one phase of the diver's activities which, in addition to the more obvious branches like wreck survey, demolition and salvage work, include surveys of the sea bed for cable routes and the like. In cases of the latter type, where for example the survey of a large area of sea mud is called for, the diver is often at a disadvantage when compared to the efficiency of instruments carried in or below a survey vessel. On a recent survey of the proposed route of a cross Channel power cable, however, the reports of a diver gave sufficient data to form a very clear picture of the nature of the bottom as deduced from echo soundings and magnetic readings taken, from a survey craft, over a large area.

In all deep diving below 100-ft. a different type of equipment becomes necessary. Mobility is of great importance to the diver both for ease of working and because, in deep diving, he is often considerable distances from his start point and has to include the double journey from base to job and back within his endurance. For this type of work re-breathing, self-contained equipment is normally used.

Work in harbours and channels is seldom carried out at a greater depth than 70-ft. and the main problems, particularly in British waters, are lack of visibility and strong tidal streams. Again, partly because of the lesser physical effort demanded of the wearer, the modern dress is at an advantage and enables a diver to remain submerged and to work under worse conditions than formerly.

New techniques for welding horizontal structures, with all the reliance that can be placed on such work undertaken above water, are being developed; new methods of drilling rock and the use of small quantities of explosives for cutting sheet piling are being perfected and in each case the characteristics of the water are being used to assist in the operation.

The rate of increasing efficiency of modern diving equipment is such that the diver is becoming less and less dependent on his surface crew and his efficiency underwater is every bit as good as that of the ordinary workman doing the same job in the dockyard.

The margin between operating costs and income with most commercial vessels today has narrowed to such an extent that even a minor mishap, if remedied in the old conventional way with the probable use of a dry dock plus the time waiting for a berth, can turn profit into loss. Under these circumstances the modern diver must become an ever increasing factor in the field of ship repair.

Publication Received

Diesel-Electric Propulsion for Ships, 28 pp. illustrated brochure, published by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

For tugs, ferries, pilot vessels, dredgers, fish factory ships, floating cranes and certain types of cargo and passenger vessel, diesel-electric propulsion has many advantages among which are fuel economy, simplicity of control, manœuvrability, flexibility in engine-room layout, and high utilisation of power produced, whether for propulsion and/or auxiliary purposes. As power is transmitted electro-magnetically, propeller shock is virtually eliminated, and the consequent lack of vibration is a particular asset for passenger ships.

The brochure states that in its simplest form, the G.E.C. diesel-electric system comprises one or more non-reversing constant-speed diesel engines, each close coupled to a d.c. generator. Each generator has a separately excited field which allows easy and immediate control and variation of the generator output. The output from the generators is used to drive a motor directly coupled to the propeller shaft. Speed and direction of rotation of the shaft respond to the output and polarity of the generated voltage.

Some installations incorporate a relay-operated anti-stalling device which ensures that, under all conditions of manœuvring, the load on the diesel engines does not exceed a predetermined amount.

The brochure contains descriptions of diesel-electric installations in each class of vessel, showing the specific advantages of the system for each type. In tugs, for instance, diesel-electric propulsion offers instant starting, the ability to develop maximum torque at the lowest propeller speed and also full power ahead and astern under all conditions.

In pilot vessels the system is economical at all speeds, whether stemming tide on station and using, perhaps, only 5 per cent of available power, or travelling at speed to a ship requiring pilot service. Similarly, with fish factory ships diesel-electric propulsion is efficient at the low speeds necessary for trawling, or at high speed when the ship is on passage to and from the fishing grounds. In addition, electrical power can easily be turned over to driving trawl winches and other auxiliaries.

Included in the brochure are data sheets giving dimensions and weights of typical electrical equipment required for installations of 200-2,000 shaft horsepower at a range of generator and propeller speeds.

Steel Dolphins in the Port of Hamburg

Varied Designs Installed Since 1950 *

Before the war, mooring dolphins almost invariably consisted of groups of timber piles interconnected by bracing. A structure of this kind might contain as many as fifty piles and derived its resistance to impact forces mainly from the presence of raking piles. It exhibited a semi-rigid behaviour in the sense that the timber bracing exercised only a limited restraining action under small horizontal loads, but that the overall stiffness of the dolphin increased under larger loads, inasmuch as the larger deflections associated with them caused "racking" and consequent tightening of the bracing. The functional behaviour of such a structure could not be calculated with any appreciable degree of accuracy.

With the increasing draughts of vessels after the war, it became more and more difficult to obtain timber piles of sufficient length for the construction of deep-water mooring dolphins, and there was a progressive change-over to steel as the structural medium. At first the designers of steel dolphins merely strove to imitate timber dolphins and made little effort to take advantage of the constructional possibilities of steel. Consequently, the early post-war dolphins were not very satisfactory, and it took several years of experiment and investigation to develop successful forms of construction.

About a hundred steel dolphins have been installed in the Port of Hamburg since 1952. In that year sixteen dolphins were constructed in the Kaiser Wilhelm Dock (Fig. 1). These structures, which replaced a series of old timber dolphins, each consist of seven seamless tubular steel piles standing in water of about 10 m depth. They have been designed to resist a pull of 70 tons (static load) at +2.3 m NN (Normal Null=German Standard Datum), and they have an energy absorption capacity of 35,000 kgm with regard to forces acting at 0.0 m NN. The piles are fabricated from lengths of tube. In the region of maximum bending moment the steel employed has a yield point of 4600 kg/cm², while the rest of the pile is made of steel with a yield point of 3600 kg/cm². The six outer piles of the dolphin have an external diameter of 521 mm and a maximum wall thickness of 18 mm (at the maximum bending moment), diminishing to 16 mm in the case of the four piles liable to come into direct contact with vessels lying alongside (14 mm in the case of the two others). The centre pile has an external diameter of 546 mm and a constant wall thickness of 18 mm. The bracings are installed at two levels and are of all-welded hollow construction (Fig. 2). The upper bracing, which is located at the level at which the mooring hawsers are secured to the dolphin (at +2.3 m NN), is supported on brackets welded to the outer piles. Torsional forces are transmitted to the central pile through a rigid transverse member that passes right through it and is welded to it . This transverse member is gripped between lugs fixed to the bracing. The lower bracing is suspended at a level of −1.75 m NN by means of three chains from the upper bracing. The central pile rises to +5.6 m NN, whereas the outer piles terminate at +3.0 m NN. The dolphin is surmounted by a superstructure composed of sloping members. The object of this is to prevent tugs and other small harbour craft running foul of the top of the dolphin at exceptionally high water levels.

The next important addition to the steel dolphins in the Port of Hamburg consisted in ten dolphins installed in the Hansa Dock in 1956/57 (Fig. 3). Each dolphin comprises five seamless tubular piles made of high-tensile steel with a yield point of 5800 kg/cm². The piles have an external diameter of 572 mm and a constant wall thickness of 14 mm. The dolphin has been designed to resist a pull of 62 tons and has an energy absorption capacity of 41,000 kgm. The bracings are of annular design, as represented in Fig. 7 (which refers to a different group of dolphins, however). The upper bracing ring, at the level at which the mooring hawsers are attached (+2.3 m NN), is provided with welded-on vertical plates which engage short curved lengths of tube passing through the four outer piles of the dolphin. The lower bracing is suspended (at −1.75 m NN) below the upper bracing, to which it is connected by a spacer tube. The central pile rises to +6.6 m NN; the outer piles are curved radially inwards from +2.8 m NN and terminate at +5.6 m NN, thus providing sloping sides to the top of the dolphin which serve the same purpose as the superstructures of the dolphins in the Kaiser Wilhelm Dock.

In 1957/58, thirteen steel mooring dolphins were installed in the Ross Dock and nineteen more, of similar design, were installed in the Waltershofer Dock (Fig. 4). The five component piles of each of these dolphins are 546 mm in diameter and have a wall thickness of 19 mm at the base,

Fig. 1. Mooring dolphins in Kaiser Wilhelm Dock.

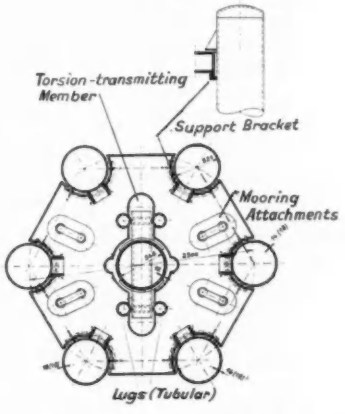

Fig. 2. Upper bracing of dolphin in Kaiser Wilhelm Dock.

Fig. 3. Mooring dolphins in Hansa Dock.

Fig. 4. Mooring dolphin in Waltershofer Dock.

* Based on "Stahldalben im Hamburger Hafen" by R. Tramborg in "HANSA," No. 16-17, 1960.

where they consist of steel with a yield point of 5800 kg/cm². At the top, the wall thickness diminishes to 14 mm, in conjunction with a yield point of 3600 kg/cm². In this case the bracings are of the hollow deck type employed on the dolphins in Kaiser Wilhelm Dock, but the outer piles are curved inwards at the top, as in the Hansa Dock. These dolphins, which stand

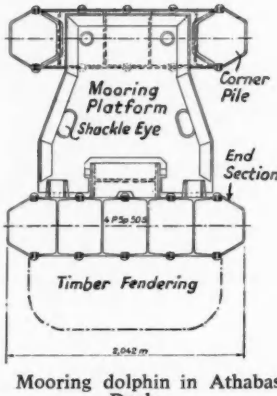

Fig. 5. Mooring dolphin in Athabaskahöft Dock.

in water of 11 m depth have been designed for a 70-ton pull and have an energy absorption capacity of 50,000 kgm.

In 1958 a set of ten four-pile steel dolphins was installed in the Strand Dock. These structures were designed to resist a pull of 70 tons and to have an energy absorption capacity of 40,000 kgm. The seamless tubular piles are 622 mm in diameter and have a constant wall thickness of 17 mm. The steel has a yield point of 5800 kg/cm² throughout. The two bracings per dolphin are of the annular type described above, but in this case there is no central pile. Instead, there is merely a short central tube rising from the upper bracing and projecting above the level of the curved-in upper ends of the piles. In 1960, sixteen dolphins generally similar to those in the Strand Dock were installed in mid-stream in the Norderelbe waterway.

In 1958 mooring facilities for two large tankers were provided in the Athabaskahöft Dock, in 12 m depth of water. Four

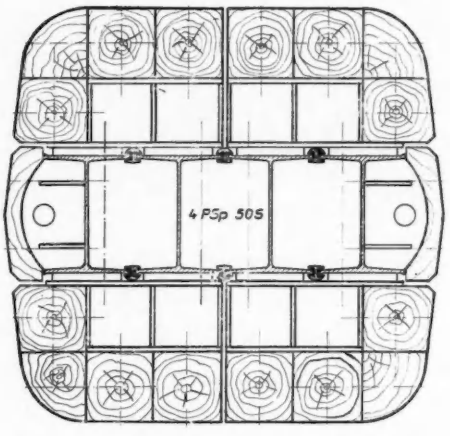

Fig. 6. Mooring dolphin in Baaken Dock (cross-section).

steel dolphins consisting of Peine sheet-piling were constructed for the purpose (Fig. 5). Each dolphin consists of two short sheet-pile "walls," connected at +2.3 m NN by a bracing platform (a 40 mm thick steel plate appropriately stiffened). Each "wall" consists of four PSp 50 S pile sections with, in addition, channel-shaped closing sections at each end. These dolphins, which are protected by timber fendering, have been designed to resist a static pull of 60 tons. The energy absorption capacity is 60,000 kgm at right angles to the front face of the dolphin, and 30,000 kgm at 45° to that face.

Four more dolphins constructed of Peine sections were installed in the Baaken Dock in 1959 (Fig. 6). In this dock the depth of water is 7 m. Each dolphin consists of a sheet-pile "wall" comprising six PSp 50 S piles (yield point 3600 kg/cm²), provided

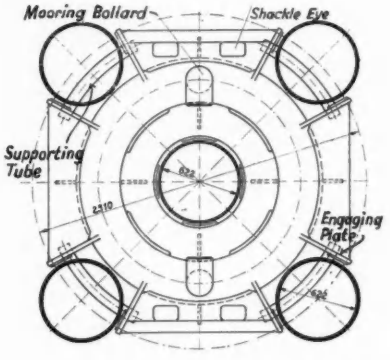

Fig. 7. Upper bracing of dolphin in Oder Dock.

with heavy timber fendering at impact level. These dolphins have been designed for a pull of 75 tons; the energy absorption capacity is 20,000 kgm.

Seven steel mooring dolphins of tubular construction, designed for a 70-ton pull and having an energy absorption capacity of 50,000 kgm, have been installed in the 11 m deep Oder Dock (Fig. 7). The piles are 622 mm in diameter and have a constant wall thickness of 16 mm; the yield point is 5600 kg/cm². The bracing employed on these dolphins is of the annular type, generally similar in design to the bracing of the Hansa Dock dolphins.

Natural By-passing of Sand at Coastal Inlets*

By PER BRUUN, F. ASCE and F. GERRITSEN
(Head and Associate Professor respectively of the Coastal Engineering Laboratory University of Florida)

In the March 1960 issue of this Journal we published extracts from a paper on "Coastal Engineering Study at Fort Pierce Inlet" which had been prepared by the Coastal Engineering Laboratory of the University of Florida. This paper discussed the unusual littoral drift in the area and suggested remedial steps which could be taken to improve the situation. In this present article, a general study is made of by-passing of littoral drift sand in harbours and channels.

At coastal inlets two main principles in by-passing of littoral drift sand by natural action occur: by-passing on off-shore bar and by-passing by tidal flow action. This article discusses these two ways of by-passing as a function of littoral drift and tidal flow characteristics of the inlet in question.

If nature did not by-pass sand across inlets, passes and channels on sea shores, a number of marine forelands including barriers, spits and entire peninsulas would not exist. A typical example of this is found in Florida, which was built up of sand washed down by rivers and streams from the Appalachian Highland and carried southward, crossing estuaries and tidal inlets, for final deposition in the huge barrier and ridge system which we call "Florida."

A submerged bar in front of an inlet or harbour entrance on a littoral drift coast will often function as a "bridge" upon which sand material is carried across the inlet or entrance. Every channel dredged through the bar will therefore be subject to deposits.

The principles involved are readily understood by the use of typical illustrations, thus, Fig. 1 (a) shows the profile of a barrier and the assumed diagram of the littoral drift, and (b) the profile through the entrance channel and the assumed diagram of the littoral drift of sand on a submerged bar: littoral drift passes along the barrier: at the downdrift end it continues on its way across the inlet on a submerged bar.

* Abstracts from a paper presented at the October 1958 Convention of the American Society of Civil Engineers held in New York.

Bar By-passing

The mechanics of bar by-passing may be a more or less continuous process or it may partly take place in greater irregular sand waves or humps which migrate across the inlet on the bar. Such by-passing cannot exist without considerable wave action and, moreover, that the depth over the bar is limited usually to the breaker depth for normal and predominant storm waves. The width of the bar is mainly a function of the velocity of the alongshore current.

It would be difficult to arrange satisfactory navigation and by-passing conditions simultaneously, because breaking waves necessary for the by-passing process are hazardous to shipping. This is the reason that inlets with bar by-passing are usually only in favour for small craft.

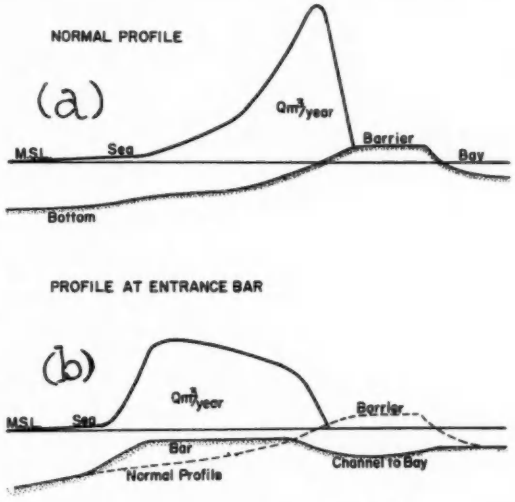

Fig. 1 (left). The principle involved in by-passing of sand on a submerged bar.

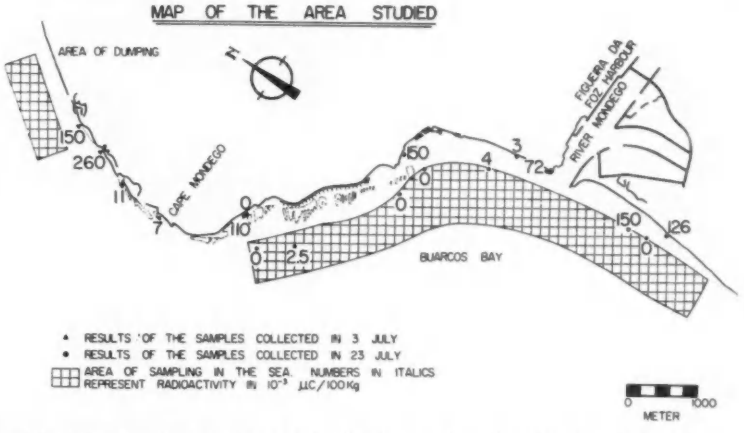
MAP OF THE AREA STUDIED
AREA OF DUMPING
CAPE MONDEGO
FIGUEIRA DA FOZ HARBOUR
MONDEGO RIVER
BUARCOS BAY
RESULTS OF THE SAMPLES COLLECTED IN 3 JULY
RESULTS OF THE SAMPLES COLLECTED IN 23 JULY
AREA OF SAMPLING IN THE SEA. NUMBERS IN ITALICS REPRESENT RADIOACTIVITY IN 10⁻³ μC/100Kg
METER

Fig. 2 (above). Tracing of radio active particles.

In Portugal, at Figueira da Foz studies have been made by the National Laboratory staff of the estuary inlet (Fig. 2) of the river Mondego. The littoral drift is north to south and the tidal range is 10-ft. The terms of reference were to

(a) investigate drifting conditions in the area of Cape Mondego and the adjacent beaches, particularly
 (i) to determine whether sand movement occurs or not from north to south beyond Cape Mondego
 (ii) to get an idea of the comparative intensity of drift in the foreshore and middle depth area.
 (iii) to study the drifting pattern along Buarcos Bay; and to estimate the speed with which sand coming from the sandy coast north of Cape Mondego reaches the mouth of the river Mondego.
(b) to determine the conditions of passage of the littoral drift material beyond the river's mouth in a north-south direction.

The investigation was carried out on site and, also on a scale model in the laboratory. As the area was of some tens of square miles and as there was no data locally of the rate of the littoral drift and the time required for the tracer material dumped into the sea about 10 kilometres north of the river's mouth, to reach the harbour, it was therefore impracticable to use a short life radioactive isotope. The requirement was at least 90 days with maximum radioactivity. Four tons of irradiated A.G.110 was chosen for the experiments. The result of these is shown in Fig. 2 (the numbers indicate counts per minute) and summarising:

(a) there is considerable drift along Cape Mondego.
(b) in the area of Cape Mondego only drift in the foreshore could be detected, as the difficulty of sampling (or measuring) prevented drift observations in the middle depth zones.
(c) it was verified that littoral drift material passed across the mouth of the river Mondego, but it was impossible to determine how this passage took place.

Apart from this example, several other practical instances of bar by-passing under limited tidal action and also of the improvement of conditions by works are given by the authors. Among the various examples described is the recent improvement of the Port of Scheveningen, Holland. Fig. 3 shows clearly the new breakwaters evolved from the tests of reduced models of the harbour for the purpose of securing a maximum of sand by-passing material with a minimum of deposition in the harbour.

By-passing by Tidal Flow Action

Where the ratio between the net littoral drift and the tidal flow is relatively small, the latter factor usually plays an important part in the successful by-passing of the material. The general sand transfer by tidal flow takes place in two different ways, namely,

(i) migration of channels and bars, and by
(ii) transport of sand by tidal flow in the channels.

(i) Tidal channels in inlets are subject to migration, that is, they may change their location continuously moving from one side of the inlet to the other. This principle is demonstrated by phases 1 and 2 of a tidal channel system (Fig. 4). Channels in phase 1 are numbered I, II, III, and IV. In phase 2 the locations of these channels have changed compared to phase 1 and a new channel "O" has developed. In this example the channels move from left to right and bars, or shoals, between the channels move in the same direction, with the result that a bar occasionally joins the down-drift side beach where the sand is distributed along the down-drift coast by waves and littoral currents. In most cases,

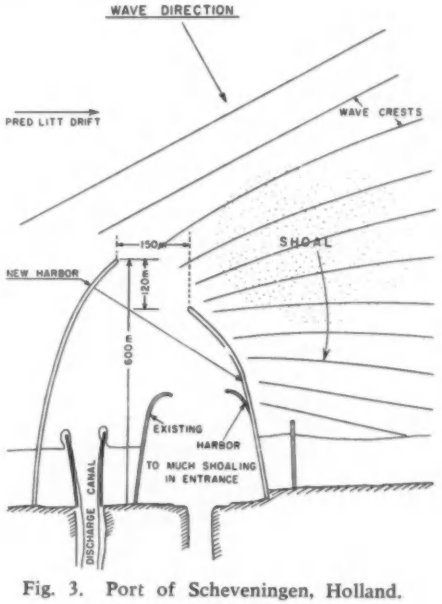

Fig. 3. Port of Scheveningen, Holland.

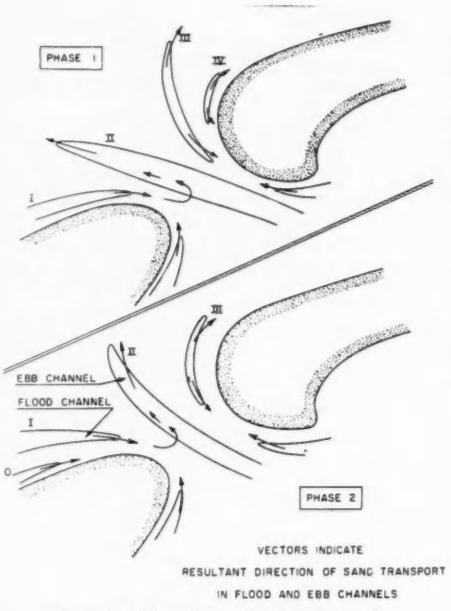

Fig. 4. Migration of tidal channels.

migration of tidal channels takes place in the direction of the littoral drift. Sand is transported over the bar under the influence of waves and deposited on the updrift bank of the channels, thus enforcing the shifting.

Because of the fact that tidal channels behave in the same way as channels in regular rivers, in curved sections, sand motion along the bottom will have a component towards the inner curve. This, in turn, will increase the rate of migration of the channel in the direction of the downdrift side curve.

(ii) In the vicinity of tidal inlets, the, (generally) strong tidal currents in the inlet change the littoral drift pattern entirely. Along an uninterrupted coast line wave action is usually the predominant cause for the transportation of the material. In the vicinity of tidal inlets however, transport of material takes place under the combined effect of waves and tidal currents.

Migration of Tidal Channels

In tidal rivers, estuaries and inlets, tidal channels can usually be identified as either flood or ebb channels. Flood channels carry predominantly flood flow, causing a resultant sand transport in a lagooned direction, they usually have a shoal at the end. Ebb channels carry predominantly ebb flow and have a resultant material transport seaward and a bar or shoal at the end. It is remarkable that ebb and flood channels never tend to be connected but always leave a bar between them over which sand migrates. In Fig. 4 vectors indicate the resultant direction of sand transport in different channels. Sand particles make a zigzag movement through the inlet from the updrift side to the downdrift side.

During the first phase in jetty improvement a great amount of sand is generally accumulated along the updrift beach. With an increasing amount of accumulation, by-passing of material gradually develops. In Fig. 5, three jetty-improved inlets are shown and in each case the ebb current has enough cleaning capacity to maintain the inlet channel by flushing action.

Adequate by-passing in such cases needs considerable wave action to move the flushed material shoreward again. A specially designed breakwater such as, say, that at Scheveningen, Holland, can utilise the tendencies of diffraction and refraction of the waves to move the sand to more advantage (see Fig. 3).

On the Dutch coast the two groups of estuaries are subject to predominant south-west wave action which causes littoral drift to the north and it is greatly assisted by a strong flood tide current. Large quantities of sand are by-passed across the Schelde nevertheless the downdrift is insufficiently nourished; unlike the adjacent inlet further north the East Schelde, where the tidal flow is weaker and the downdrift beach is adequately supplied.

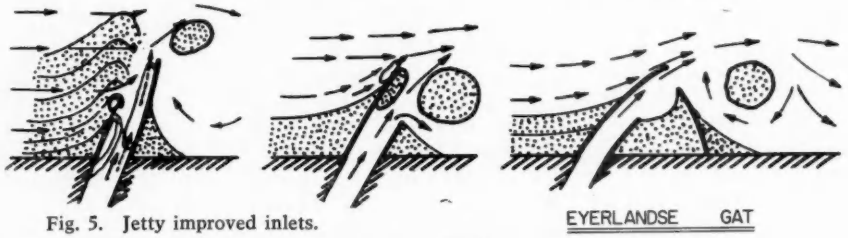

Fig. 5. Jetty improved inlets.

Vlie inlet (Fig. 6) leading into the Wadden Zee has particular interest as the arrows indicate the zigzag movement of sand about the inlet and show the complexities of the problem. The transfer is adequate but nourishment of the downdrift shore takes place intermittently in the form of sand waves with decreasing amplitude downdrift as demonstrated by detailed surveys (see Fig. 6).

Summing Up

It will have become clear that natural by-passing depends upon a number of different factors, such as littoral drift magnitude, including long shore current velocity and wave action; quantity and velocity of tidal flow, and material characteristics. These variables are not independent, and depend themselves on other parameters, as for example, shore line and offshore line bottom configuration, and other geological and geographical factors.

As a first approximation those factors which seem to have a predominant influence on by-passing are considered thereby ignoring those variables whose effects are probably of secondary importance. Although the material characteristics obviously are of importance in the by-passing mechanism, this parameter can be eliminated if considerations are restricted to inlets on sandy coasts with grain size 0.15 to 0.5 mm. Within this group the variation in grain size material does not seem to have predominant effect on the by-passing procedure and mechanism.

Accordingly the by-passing factor P is tentatively written as follows:

$$P = f\left(\frac{E_{wa}}{M_{mean}}, \frac{M_{mean}}{Q_{max}}, \frac{M_{max} - M_{mean}}{M_{mean}}\right)$$

in which

P=by-passing factor

E_{wa}=wave energy of waves of a certain period from a certain direction

M_{max}=maximum littoral drift (cu. yds. per year)

M_{mean}=mean littoral drift (cu yds. per year)

Q_{max}=maximum tidal flow through the inlet (cu yds. per sec.)

EYERLANDSE GAT

Fig. 6. Resultant sand transport vectors in "Eyerlandse Gat."

whilst this impression is not homogeneous it has been found useful as a working hypothesis.

The parameter $\frac{E_{wa}}{M_{mean}}$ depends on the amount of wave energy and on the angle of approach of the waves with the shore line.

By-passing of Sand—continued

Considering cases where fair natural by-passing has been established at inlets as, for example several of the cases examined above have a common characteristic; they all represent inlets with moderate to heavy wave action, causing much stir-up of littoral drift material. As a consequence of this—littoral drift is strong with considerable suspended material load utilising the transport capacity of longshore currents. In all cases by-passing is a rather continuous operation without long interruptions.

With reference to Fig. 1 it can therefore be said that bar by-passing is possible whenever wave action and longshore currents, without being obstructed too abruptly by any configuration of natural, or artificial, matter are able to build up a "bar bridge" to carry the sand load.

The dimensionless parameter $\frac{M_{mean}}{Q_{max}}$ is however a useful relationship for the by-passing mechanism. The value of this ratio indicates whether by-passing is predominantly "bar bridge" or predominantly "tidal flow transfer," by which material is flushed out of the inlets by ebb currents carrying the material in the downdrift direction.

Consideration of data of about 30 inlets shows that the ratio "r" $= \frac{M_{mean}}{Q_{max}}$ varies in the thirty inlets studied, from 5 to 900, but there was more definite information when the groupings were as below

"r"<10-20 for those inlets predominantly tidal flow by-passing; and

"r">200-300 for those inlets predominantly bar by-passing.

Conclusions

For navigation, the inlets may be designed to assist nature in by-passing by increasing the turbulences or by streamlining jetty construction. If possible irregularities in the littoral drift magnitude should be equalised; for example at Thorsminde, Denmark, groynes have been constructed on the updrift side to regulate littoral drift; the updrift jetty has been extended to establish transfer in deeper water and drainage sluices have been provided for flushing the entrance when necessary. Navigation conditions are now satisfactory for craft up to 6-ft. draft and a natural by-passing of about 500,000 cubic yards per year.

At Aveiro, Portugal, a long term trial and error process resulted in a funnel-shaped entrance in which the curvature of the updrift jetty is particularly advantageous for by-passing. At Figueira da Foz, model experiments are in progress and a similar solution regarding inlet stability and by-passing is sought. The present natural by-passing is reasonably satisfactory but greater depth is required on the bar.

No general formula or theory exists for the proper design of inlets for by-passing but if favourable natural conditions exist the most effective and speedy investigation is that of reduced model experiment prior to any major works.

It is usually difficult to avoid leeside erosion but improvement can be gained by using a streamlined jetty on the downdrift side.

Manufacturers' Announcements

New Company for Cargo Handling Equipment

A Company has recently been formed jointly by Herbert Morris Ltd., Loughborough, and Butters Bros. & Co. Ltd., Glasgow, to foster the development, design and marketing of engineering equipment of interest to both firms. The new Company, Morris & Butters Ltd., registered at Motherwell, will operate from the office of Butters Bros. & Co. Ltd. at Hillingdon, Middlesex. Mr. Benjamin Butters, a Director of Butters Bros. has been appointed Chairman of the new joint venture with Mr. Alex Sykes, late of Rendel, Palmer and Tritton, consulting engineers, as Managing Director.

Pneumatic Capstans for Oil Terminals

The Globe Pneumatic Engineering Company Limited of Romford, Essex, have recently designed and supplied pneumatic capstans for use on marine terminals by oil companies.

The capstan is driven by a four-cylinder piston type radial air motor of 5 h.p. capacity which supplies a high starting torque through a worm type reduction gear box to a vertical capstan head. The whole unit is totally enclosed to prevent ingress of sea water and meets the design and specification of a starting pull of 2,500 lbs. and a running pull of 1,000 lbs with a rope speed of 90-ft. per minute. The unit is designed to work from an air pressure of 90 p.s.i. and the approximate consumption is 150 cu. ft. F.A.P.M.

The pneumatic capstan has all the advantages of the piston type air motor in so far as it is completely flameproof, is not affected by the wet conditions experienced on exposed jetties, has an infinitely variable speed and can be stalled without damage. A foot control valve is supplied with the capstan, and this forms a shroud over the valve protecting the working parts from damage by sea spray and general damage experienced on an exposed site.

New Underwater Closed Circuit Television

A new service which makes use of closed-circuit television for underwater and pipeline inspection is to be demonstrated at the Engineering, Marine, Welding & Nuclear Energy Exhibition which opens at Olympia, London, on April 20. Two different types of camera are employed—one for underwater inspection and the other for the inspection of sewers and pipelines.

(Photo P.L.A.)

Diver preparing to descend with Turbid Water Camera for survey of Shadwell Entrance Lock—middle cill.

Manufacturers' Announcements—continued

The underwater television camera is able to 'see' through **turbid** water—hitherto a tremendous handicap in the inspection of objects and structures underwater as, in these conditions, divers have had to rely solely on touch. This aspect of the new service will therefore be of especial interest to dock and harbour authorities, river boards, marine salvage contractors and to marine and consulting engineers.

The second type of camera is explosion-proof and is primarily used in the inspection of pipelines and sewers, of diameters down to 9-in. It is either winched through the pipe or sewer or, where there is running water, floated along. A miniature version, which can also be used for borehole inspection, is available for diameters down to 3-in.

Each type of camera carries its own lighting system and transmits pictures to a monitor mounted in a specially equipped inspection vehicle. Still or cine photographs can be taken of the screened picture to serve as permanent records. Both types of apparatus are being exhibited by General Descaling Co. Ltd., of Worksop, Notts.

Smith Dockside Crane for Dover Harbour

Thomas Smith & Sons (Rodley) Ltd., announce the receipt of an order from the Dover Harbour Board for a 3-ton electric level-luffing dockside crane. This crane is a repeat order and follows two of a similar type which were installed a few years ago and which have been found extremely satisfactory in service. The crane is able to lift its maximum load of 3 tons at 55-ft. radius, and its rapid operation makes it particularly well suited for dockside duties, where speed of loading and unloading is of considerable importance.

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CLASSIFIED ADVERTISEMENTS

Rates 4s. per line (minimum 8s.); Box Number 2s. extra; Rate for single column inch is £2 per inch. Prepayment of classified advertisements is requested. Orders should be sent to Advertisement Department, "The Dock and Harbour Authority," 19. Harcourt Street, London, W.1. Telephone: PAD 0077.

APPOINTMENT VACANT

THE FALMOUTH DOCKS AND ENGINEERING COMPANY

Applications are invited for the appointment of Assistant Civil Engineer at a salary in accordance with qualifications and experience, but not less than £1,000 p.a. The successful candidate will be superannuated under the Company's scheme after a probationary period.
The Company is the Statutory Authority for Falmouth Docks and the work will consist of the design and supervision of capital works and maintenance in connection with the docks installations.
Applicants should be Chartered Civil Engineers and previous experience of marine civil engineering will be an advantage.
Applications stating age, education, qualifications and experience should be sent, as soon as possible, to:

The Falmouth Docks and Engineering Company,
The Docks, FALMOUTH, Cornwall.

FOR HIRE

MODERN FORKLIFTS available for five year hire contracts, £15 per week. Box No. 243, "The Dock and Harbour Authority," 19 Harcourt Street, London. W.1.

WANTED

BALL AND ROLLER BEARINGS ETC. WANTED. Also surplus goods —especially Hand Tools—of all descriptions. R. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

NATO COMMON INFRASTRUCTURE
SLICE VIII
NAVAL BASE INSTALLATIONS

1. FINAL NOTICE is hereby given that International Competitive Bids will be invited on or about 1st JUNE, 1961, for the construction of a P.O.L. STORAGE DEPOT in the CAMPBELTOWN AREA OF SCOTLAND.
2. The approximate total value of the works is £2,250,000 and the contract will comprise:
   (i) The supply and construction of semi-buried steel storage tanks and associated pipelines.
   (ii) The provision and installation of pumps, boilers, steam heating, electrical generating and distribution systems.
   (iii) The construction of roads and footpaths and miscellaneous buildings.

   Alternative bids will be called for to include prestressed concrete semi-buried storage tanks instead of steel as stated above.
3. Separate Final Notices are being issued in respect of the Specialist Steam, Pumping and Electrical Equipment and Electrical Installation work which are to form the subjects of sub-contracts within the above main contract.
4. The construction of the Jetty facilities associated with this depot forms the subject of a separate contract for which the Final Notice will be issued shortly.
5. It should be noted that the importation of labour from sources outside the United Kingdom may be subject to restriction and that permission could, in any case, only be given on an undertaking that the Contractor would pay rates of wages and observe hours and conditions of labour not less favourable than those established for U.K. labour for the trade or industry in the same area.
6. The closing date for the receipt of bids will be 24th August, 1961.
7. Firms wishing to bid must formally notify their desire by application to the address below by 1st April, 1961.
8. Within one week after the closing date for the receipt of applications to bid, firms wishing to be invited must forward the following information:
   (i) Statement of financial resources and evidence of financial stability.
   (ii) Details of recent major contracts completed for work of a comparable nature including an indication of the value of each.
9. Enquiries regarding bidding should be addressed to:
   DIRECTOR GENERAL, NAVY WORKS, ADMIRALTY,
   CHAMBERLAIN WAY, PINNER,
   MIDDLESEX, ENGLAND.

quoting Reference NWD/Infra/19.